FEAS Survey Series: 2013/04

Northwest Herring Acoustic Survey Report

22nd June – 12th July, 2013

RV Celtic Explorer

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Photo: Barra Head, Tommy Torrades

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1 Introduction

The northwest and west coast (ICES Divisions VIaS & VIIb, c) herring acoustic survey programme was first established in 1994. Prior to acoustic estimation, a larval survey programme was conducted from 1981-1986. In the early 1990s, the ICES herring working group (HAWG) identified the need for a dedicated herring acoustic survey in this area (Anon, 1994). From 1994 to 1996 surveys were carried out on this stock during the summer feeding phase. In 1997 a two-survey spawning survey was established covering both autumn and winter components. In 2004, this was modified to a single spawning stock survey which was carried out early in quarter 1 and continued until 2007. In 2008, it was decided that this survey should be incorporated into the larger coordinated Malin shelf summer survey on recommendation from SGHERWAY and WGHAWG.

The summer 2013 survey represents the sixth in the new time series (est. in 2008). The survey was coordinated through the ICES Working Group of International Pelagic Surveys (WGIPS). The Irish component was carried out to cover the statistical rectangles between 53°30'-58°30' N and 12°-5° W as laid out in the WGI PS report (ICES, 2012). Combined survey data on herring distribution, abundance and age are used to provide a measure of the relative abundance of herring within the Malin shelf stock complex. Survey data on stock numbers at age are submitted to the ICES Herring Assessment Working Group (HAWG) and used in the annual stock assessment process.

The northwest and west coast (ICES Divisions VIaS & VIIb) herring stock is composed of two spawning components, autumn and winter spawners. Spawning covers a large geographical area and extends over a 4-month period from late September through to late March (Molloy *et al*, 2000). Traditionally, fishing effort has been concentrated on spawning and pre-spawning aggregations. The autumn spawning component, which mostly occurs within VIIb and VIaS, feeds along the shelf break area to the west of the spawning grounds. The larger winter spawning component is found further north in VIa. In VIaS, summer distribution extends from close inshore to the shelf break. Components of the winter spawning fish are known to undertake northward feeding migration into VIaN before returning in the winter to spawn along the Irish coast.

2 Materials and Methods

2.1 Scientific Personnel

Name	Institute	Capacity
Marcin Blaszkowski	FEAS	Biologist
Rob Bunn	FEAS	Acoustic
Andrew Campbell	FEAS	Acoustic
Hannah Keogh	IWDG	MMO**
Amy Lusher	GMIT	Microplastics
Michael McAuliffe	FEAS	Biologist
Eugene Mullins	FEAS	Acoustic
Cormac Nolan*	FEAS	Acoustic
Turloch Smith	FEAS	Biologist
Mairead Sullivan	FEAS	Biologist
Tommy Torades	TTRS***	Biologist

* Chief scientist
**Marine mammal observer
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2.2 Survey Plan

2.2.1 Survey objectives

The primary objectives of the survey are listed below:

- Carry out a pre-determined survey cruise track based on the known summer herring distribution
- Collect biological samples from directed trawling on fish echotraces to determine age structure and maturity state of survey stock
- Determine an age stratified estimate of relative abundance and biomass of herring within the survey area (ICES Divisions VIIb & VIaS-N) using acoustic survey techniques
- Collect physical oceanography data as horizontal and vertical profiles from a deployed sensor array.
- Collect detailed morphometric data on individual herring to contribute to stock discrimination studies for SGHERWAY
- Collect acoustic and biological data on boarfish (*Capros aper*) to feed into the Boarfish Acoustic Survey, 2013.
- Record marine mammal and seabird sightings

2.2.2 Area of operation and survey design

The survey focused on the northwest and west coast of Ireland and the west coast of Scotland (ICES Divisions VIaN & VIaS and VIIb) as shown in Figure 1. The survey track started to the southeast of the Isle of Coll, zigzagged north through the Minches (between the Scottish mainland and the Hebrides), then worked progressively southwards in parallel transects, before finishing near the mouth of Killary Fjord.

A systematic parallel transect design was adopted for the majority of the survey, with a randomised start point. Transects were positioned running perpendicular to the lines of bathymetry where possible. Transects were generally positioned between the 30 m and 250m depth contours. Transect spacing was set at 7.5 nmi in the main body of the survey and at 15 nmi between 57°and 58.5℃N. A zigzag design was uti lised in the Minches region.

To keep in line with existing survey methodology acoustic data collection was only undertaken during daylight hours (04:00 and 00:00).

In total, the survey covered 2,946nmi, 2,179nmi of which were on transect and suitable for acoustic integration. Survey design and methodology adheres to the methods laid out in the PGHERS acoustic survey manual.

2.3 Equipment and system details and specifications

2.3.1 Acoustic array

Equipment settings (Table 1) were determined before the start of the survey and are based on established settings employed on previous surveys (O'Donnell *et al.,* 2004).

Acoustic data were collected using the Simrad EK60 scientific echosounder. A Simrad ES-38B (38 kHz) split-beam transducer is mounted within the vessels drop keel and lowered to the working depth of 3.3 m below the vessels hull or 8.8 m below the sea surface. Data were also collected at operating frequencies of 18, 120 and 200 kHz during the survey. Estimates of herring abundance and biomass were derived exclusively from 38 kHz data.

While surveying on track, the vessel is powered using DC twin electric motor propulsion system with power supplied from 1 main diesel engine, so in effect providing "silent cruising" as compared to normal operations (Anon, 2002). Cruising speed is maintained at a maximum of 10Kts (knots) where possible. During fishing operations, normal 2 engine operations were employed to provide sufficient power to tow the net.

2.3.2 Calibration of acoustic equipment

The EK60 was calibrated behind St. John's Point, near Killybegs on the 24nd of June before the survey start point to ensure optimal operation of the echosounder during data logging. A second calibration could not be performed at the end of the survey due to time constraints. The results of the 38 kHz calibration are presented in Table 1. Prior to the survey, the EK60 was last calibrated in April 2013.

2.3.4 Acoustic data acquisition

Acoustic data were recorded onto the hard-drive of the EK60 processing PC. The raw ER60 files were copied via a continuous Ethernet connection to the vessels server as a backup in the event of system failure. Further back-up copies were stored on an external HDD and magnetic LTO2 tapes. Myriax Echoview Echolog (Version 4.8) live-viewing software was used to display the echogram during data collection to allow the scientists to monitor target locations and depths of fish shoals in almost real-time. A member of the scientific crew monitored the equipment continually. Time and position were recorded for each transect start/end point within each strata. The log was also used to record "off track events" such as fishing operations and hydrographic stations.

2.3.5 Echogram scrutinisation

Acoustic data was backed up every 24 hrs and scrutinised using Myriax Echoview (vers. 4.8). The scrutiny process involved the allocation of echotraces (schools) to particular species or species mix categories, based on the information from the directed trawl hauls.

The NASC (Nautical Area Scattering Coefficient) values from each herring echotrace were allocated to one of 4 categories after scrutiny of the echograms. Categories identified on the basis of echotrace scrutiny were as follows:

1. "Definitely herring" echotraces or traces were identified on the basis of captures of herring from the fishing trawls which had sampled the echo-traces directly, and on large echotraces which had the characteristics of "definite" herring traces (i.e. very high intensity (red), narrow inverted tear-shaped marks either directly on the bottom or in mid-water and in the case of spawning shoals very dense aggregations in close proximity to the seabed).

2. "Probably herring" were attributed to smaller echotraces that had not been fished but which had the characteristic of "definite" herring traces.

3. "Herring in a mixture" were attributed to NASC values arising from all fish traces in which herring were thought to be contained, owing to the presence of a proportion of herring within the nearest trawl haul or within a haul which had been carried out on similar echotraces in similar water depths.

4. "Possibly herring" were attributed to small echotraces outside areas where fishing was carried out, but which had the characteristics of definite herring traces.

Echograms were divided into transects and off track events, including trawl hauls and hydrographic stations were excluded. Echo integration was performed on regions which were defined by enclosing selected parts of the echogram that corresponded to one of the four categories above. The echograms were generally analysed and echo-integrals calculated, at a threshold of -70 dB, where necessary heavy backscatter from plankton was filtered out by thresholding at –65 dB.

2.3.6 Biological sampling

A single pelagic multipurpose midwater trawl with the dimensions of 54m in length (LOA) and 8m at the wing ends and a fishing circle of 420m was employed during the survey (Figure 13). Mesh size in the wings was 2.2m through to 4cm in the cod-end. The net was fished with a vertical mouth opening of approximately 22m, which was observed using a cable linked "BEL Reeson" netsonde (50 kHz). Spread between the trawl doors was monitored using Scanmar distance sensors, all sensors being configured and viewed through a Scanmar Scanbas system.

All components of the catch from the trawl hauls were sorted and weighed; fish and other taxa were identified to species level. Fish samples were divided into species composition by weight. Species other than herring were weighed as a component of the catch and length and weight measurements were taken for 100 individuals in addition to a 300 fish length frequency sample. Age, length, weight, sex, and maturity data were recorded from 100 random herring, a further 100 random length/weight measurements were also taken, in addition to a 300 fish length frequency sample from each trawl. All herring were aged onboard. The appropriate raising factors were calculated and applied to provide length frequency compositions for the bulk of each haul.

Decisions to fish on particular echo-traces were largely subjective, though an attempt was made to target all significant fish mark-types throughout the survey grid regardless of subjective eye-ball classifications. No bottom trawl gear was used during this survey.

2.3.7 Oceanographic data collection

Hydrographic stations were carried out during the survey at predetermined locations along the track. Data on temperature, depth and salinity were collected using a Seabird 911 sampler from 1 m subsurface to full depth.

2.3.8 Marine mammal and seabird survey

A marine mammal observer was present onboard during the survey and conducted watches from the crows nest (18m above sea level) and the bridge (when wind speed measured above 22kns). Observer effort focused on a 90º arc ahead of the ship; however sightings located up to 90º port and starboard were also included. The observer scanned the area by eye and by using 8 X 42 binoculars. Bearings to sightings were measured using an angle board and distances were estimated with the aid of distance measuring stick. Environmental data were recorded every 15 minutes using Logger 2000 software. Sightings were also recorded using Logger 2000. Automated position data were obtained through a laptop computer linked to GPS receiver. Surveying was conducted up to Beaufort sea-state 6 and in visibility ≥ 500m. As this was a survey onboard a vessel of opportunity, cetaceans sighted were not approached. Sightings were identified when possible, or downgraded to unidentified whale or unidentified dolphin.

2.4 Analysis methods

2.4.1 Abundance estimates

The recordings of area back scattering strength (NASC) per nautical mile were averaged over a one nautical mile EDSU (Elementary sampling distance unit), and the allocation of NASC values to herring and other acoustic targets was based on the composition of the trawl catches and the appearance of the echotraces.

To estimate the abundance, the allocated NASC values were averaged for ICES statistical rectangles (1° latitude by 2° longitude). For each statistical area, the unit area density of fish (S_A) in number per square nautical mile ($N*nmi^{-2}$) was calculated using standard equations (Foote et al. 1987, Toresen *et al*. 1998).

NASC values assigned according to scrutinisation methods (section 2.3.5) were used to estimate the boarfish numbers according to the method of Dalen and Nakken (1983).

The following TS-length relationships used were those recommended by the acoustic survey planning group (ICES, 1994):

Herring	TS = $20\log_{10}L$ – 71.2 dB per individual (L = length in cm)
Sprat	TS = $20\log_{10}L$ – 71.2 dB per individual (L = length in cm)
Mackerel	TS = $20\log_{10}L$ – 84.9 dB per individual (L = length in cm)
Horse mackerel	TS = $20\log_{10}L$ – 67.5 dB per individual (L = length in cm)

The TS length relationship used for gadoids was a general physoclist relationship (Foote, 1987):

Gadoids	TS = $20\log_{10}L$ – 67.4 dB per individual (L = length in cm)

For boarfish (*Capros aper*) a species specific TS length relationship was applied based on theoretical swimbladder modelling (Fassler *et al.* 2013).

Boarfish TS = $20\log_{10}L - 66.2$ dB per individual (L = length in cm)

To estimate the total abundance of fish, the unit area abundance for each statistical rectangle was multiplied by the number of square nautical miles in each statistical square and then summed for all statistical rectangles for the total area. Biomass estimation was calculated by multiplying abundance in numbers by the average weight of the fish in each statistical rectangle and then sum of all squares by rectangle and summed for the total area.

3 Results

3.1 Herring abundance and distribution

Twenty two hauls were carried out during the survey of which 19 contained herring (Figure 2, Table 2). 4,430 herring lengths were taken, together with 2,901 length/weight measurements and 1,591 individual age readings. Twelve hauls were sampled for the SGHERWAY stock identification project (Figure 2), resulting in 1,271 body morphometry photographs and otoliths for shape analysis.

3.1.2 Herring biomass and abundance

Total herring abundance, biomass and SSB for the whole area surveyed by Celtic Explorer are summarised in the table below.

	Abund. (millions)	Biomass (t)	% Contribution
All herring			
Def Herring	518	80,688	68
Herring in a mix	66	11,936	10
Probably Herring	172	26,255	22
Possibly Herring	41	6,263	
Total excl. poss.	**756**	**118,879**	
Spawning stock			
Def Herring	373	62,463	67
Herring in a mix	61	11,260	12
Probably Herring	112	18,852	20
Possibly Herring	28	4,592	
Total excl. poss.	**546**	**92,575**	

The total stock biomass was estimated at 118,879 t, which is approximately a 70% reduction from the 2012 estimate of 397,800 t. There was a similar reduction in SSB to 92,575 t.

In ICES area VIaN, total herring biomass (TSB) was 73,400 t, total herring abundance (TSN) was 455 million individuals, and spawning stock biomass (SSB) was 73,300 t.

TSB was 42,100 t in ICES area VIaS, the TSN was 279 million individuals, and the SSB was 42,100 t.

ICES area VIIb had the lowest biomass, with a TSB of 3,400 t, a TSN of 22 million individuals, and an SSB of 3,400 t.

A full breakdown of the survey stock structure by strata, age, length, maturity and area is presented in Tables 4-8.

3.1.3 Herring distribution

In total, 654 herring echotraces were recorded during the survey (Table 9), the majority in VIaN (Figure 3). Herring were predominantly distributed between the shelf-break and 8° W. No schools were seen in the Minches region, unlike 2012 when a number of juvenile herring schools were encountered. As in 2012, the greatest concentration of herring was seen in stat rectangle 42E1 in VIaN and the second highest in stat rectangle 38E0 in VIaS. A small number of large schools were observed to the west and north-west of Donegal but overall

there were far fewer large schools seen in 2013 compared to the previous year. For example in 2013 only seven herring schools had an NASC of over 1,000, whereas there were 28 in 2012.

The majority of herring occurred in discrete, small schools in close proximity to the seabed (see Appendix 1; e.g. Hauls 6, 8 and 17) or in mixed-species assemblages, forming a light scattered layer along the seabed with mackerel and boarfish (Table 2; Appendix 1 Hauls 5, 8, 22). These layers often extended for several miles. No herring schools were observed in the upper regions of the water column. Very few large, mid-water schools were encountered and herring were broken up into smaller schools with a more uniform distribution than 2012 (Figure 3).

Similar to previous surveys, very few herring were observed in VIIb. Those that were, were seen in small schools in close proximity to juvenile blue whiting on the shelf.

3.1.4 Herring stock structure

Age analysis of biological samples showed herring within the survey area to be composed of age-groups from 2-10 years (winter rings; Tables 4-6). Overall, the stock age profile was dominated by 3-ring (30.1%) and 4-ring (38.4%) herring in terms of biomass (Table 5), and 3-ring (33.6%) and 4-ring (35.1%) in terms of abundance (Table 6). This trend in stock structure was similar for all the regions surveyed (VIaN, VIaS, VIIb). No age 0 or 1 herring were encountered in the entire survey and only 12.7% of the estimated 757 million herring were aged 2. In 2012 608 million herring (23.3% of the total abundance) were estimated to be 1-ringers. This cohort was not evident in the 2013 survey. Inspection of the length-frequency data showed that the smallest herring sampled were 21cm in length, compared to 17cm in 2012 (Table 3).

Combined maturity analysis indicated that, similar to 2012, 22.1% of the TSB was immature, with this group comprising 27.7% of the TSN. The majority of herring encountered during the survey were spent fish (57% by biomass, 52.5% by abundance; Tables 7 and 8).

3.2 Other Pelagics

3.2.1 Boarfish

Boarfish (*Capros aper*) were encountered from 70-140 m and were distributed mainly in areas VIaS and VIIb close to the shelf-break (Figure 5). The majority of the boarfish that was detected acoustically occurred in small or medium sized schools close to bottom on the shelf break (see Appendix 1; Haul 9 and 14).

Overall, 465 individual length measurements and 203 length/weight measurements were recorded from four hauls. Boarfish length ranged from 11.5-16.5 cm with a corresponding weight range of 32-97 g. Mean length was 14.5 cm and mean weight 62 g.

Estimates of boarfish abundance and biomass are not reported here because the data were combined with those collected over a much wider area as part of a dedicated boarfish acoustic survey (see O'Donnell et al. 2013).

3.2.2 Mackerel

Mackerel were encountered in most hauls, occasionally making up over 54% of the total catch. They were distributed over the entire survey area, usually as mixed species scattering layers.

In total 1,197 individual lengths and 860 length/weight measurements were recorded for mackerel from 16 hauls. Length ranged from 18-43 cm with a corresponding weight range of 43-599 g. Mean length was 28.9 cm and mean weight 231 g.

3.3 Oceanography

A total of 42 CTD casts were made during the survey (Figure 1). All data were compiled to produce horizontal plots of temperature and salinity at the following depths; 5m, 20m, 40m and 60m subsurface (Figures 6-9).

The hydrographic data showed that, similar to 2012, the upper regions of the water column (5 & 20 m) in VIaS (northwest Ireland) were considerably warmer than the VIaN region (c. 13.6 ℃ cf. 11.9 ℃ north of 56℃N; Figure 6 and 7). At 4 0 and 60 m, the water temperature was much cooler throughout most of the survey sector (c. 10.5 ℃), indicating that the water was well-stratified thermally in all regions except for those off Mayo (area VIIb; Figure 9). As with the 2012 survey, water temperatures north of Mayo were high throughout the water column (between 5 and 60 m), suggesting a high degree of mixing in this region. Our results showed generally that the water salinity decreased gradually from the shelf-break (c. 35.4 ppt) towards land (c. 34 ppt) at all depths surveyed through the survey region (Figures 6-9). Salinity was fairly uniform throughout the water column, varying by approximately 0.1 to 0.5 ppt between the upper layers and 60 m.

In general, the spatial pattern in temperature variation in 2013 was similar to that in 2012, with coastal waters around northwest Ireland being predominantly warmer than those in the northern and shelf-break regions. One difference however, was that the pool of cold water (< 10℃) found at 40m in 2012 did not extend as far so uth in 2013 (Figure 9). The southern limit of the cold water in 2013 was at roughly 56° N, com pared to 55℃N in 2012.

3.4 Marine Mammals and Seabirds

3.4.1 Cetacean activity

Forty seven sightings of 8 species of cetaceans, common seal (*Phoca vitulina*), grey seal (*Halichoerus grypus*), basking shark (*Cetorhinus maximus*), sunfish (*Mola mola*), and 40 unidentified dolphins and 1 unidentified whale were recorded (Table 12). Fourteen sightings of cetaceans were seen outside observer hours or in sea state +6. Common dolphins (*Delphinus delphis*) were the most abundant species of cetacean seen throughout the survey. The greatest diversity of species was recorded around the northern Minches: common dolphin (*Delphinus delphis*), minke whale (*Balaenoptera acutorostrata)*, Atlantic white-sided dolphin (*Lagenorhynchus acutus)* and orca (*Orcinus orca*). Figures 11 and 12 show the distribution of sightings over the survey area.

3.4.2 Seabird activity

Daily species list were recorded of all bird species seen. Sixteen species of bird were observed during the survey:

Great skua	(*Stercirarius skua*)
Great black backed gull	(*Larus marinus*)
Lesser black backed gull	(*Larus fuscus graellsii*)
Herring gull	(*Larus argentatus*)
Common gull	(*Larus canus canus)*
Kittiwake	(*Rissa tridactyla*)
Common tern	(*Sterna hirundo*)
Gannet	(*Morus bassanus*)
Great northern diver	(*Gavia immer*)
Guillemot	(*Uria aalge*)
Razorbill	(*Alca torda*)
Puffin	(*Fratercula arctica*)

Fulmar	(*Fulmarus glacialis*)
Manx shearwater	(*Puffinus puffinus*)
Sooty shearwater	(*Puffinus griseus*)
Stormpetrel	(*Hydrobates pelagicus*)

3.4.3 Environmental conditions

Environmental data were collected at 479 stations. A Beaufort sea state of 0 was recorded at 5% of the environmental stations, 1 at 30.5%, 2 at 29.8%, 3 at 16.3%, 4 at 7.9%, 5 at 5.7% and sea state 6+ at 4.8%.

Visibility of 6 (20km+) was recorded at 42.5%, 5 (16-20 km) at 34.3%, 4 (11-15 km) at 5.6%, 3 (6-10 km) at 3.5%, 2 (1-5 km) at 4% and 1 (< 1km) at 10.2% of the stations. No swell was recorded at 54.5%, a light swell of 0-1 at 34.9%, a moderate swell of 1-2 at 9.1%, and a rough swell at 1.5%. No precipitation was recorded at 81.4%, while rain was recorded at 6.1%. Fog/mist was recorded at 12.5% of the stations.

Altogether 5 days were lost due to bad weather (sea state 6+, heavy swell of 2m+, or dense fog restricting visibility).

4 Discussion and conclusions

4.1 Discussion

All components of the work program were completed as planned. The ER60 echosounder was calibrated prior to beginning the planned cruise track and an intercalibration with the MFV Felluca was conducted before the start of the 2013 boarfish acoustic survey (results pending). The entire survey grid was completed but, due to high winds and heavy seas, progress was slowed considerably during the first two weeks of the survey. Speed over ground was slowed to 4 knts on a number of days, particularly on the east to west transects. In order to cover the necessary statistical rectangles in the remaining time, transect spacing was increased from 7.5 nmi to 15 nmi between 53.5ºN and 55ºN (stat rec tangles 36D8, 36D9, 37D9, 37E0, 37E1, 38D9, 38E0, 38E1, Figure 4). This equated to a 300 nmi reduction in the planned survey track but ensured all stat rectangles were still covered. The eight rectangles with reduced coverage generally showed low herring biomass in previous surveys. The estimates of abundance and biomass had a relatively high degree of precision, with CVs around 21.5%, and the acoustic analyses were supported by a relatively high number of net hauls.

In 2011 this survey was extended substantially to cover regions in VIaN that were previously surveyed by Marine Scotland. This is the third year that the entire survey area was covered by the Marine Institute and the results are therefore directly comparable to those of 2011 and 2012. Estimated TSN for the entire area in 2013 was 757 million individuals, with a TSB of 118,879 t and an SSB of 92,575 t. This represents a decrease in TSN, TSB and SSB of 71%, 70% and 70% respectively over 2012 figures.

Areas VIaS and VIIb have been consistently surveyed since 2008 so the biomass estimates from these areas in 2013 can be considered comparable to the previous five years. There has been a decrease in TSB from 68,300 t in 2012 to 45,500 t in 2013. Table 10 shows that such large fluctuations are common. Care should be taken in interpreting these results as herring are a highly mobile and migratory species and they frequently migrate northward from regions around Ireland during the summer months. It is therefore possible that the large fluctuation seen in this year's survey could be due inter-annual variation of acoustic abundance estimates, some larger abiotic influence, or a combination of both. A more accurate estimate of the overall Malin Shelf herring population will emerge when the results of the current survey are added to those of the RV Scotia at the next WGIPS meeting (January 2014).

It was apparent during the survey that the majority of the observed herring was broken up into smaller, less dense schools in contrast to previous years: the greatest recorded NASC value (6,700) was only two thirds that of the 2012 survey. In addition, very few large, dense mid-water marks were encountered, with only seven herring echotraces having an NASC above 1,000 (compared to 28 in 2012). Personal communication with other researchers on vessels participating in the combined survey corroborated this finding.

It is interesting to note that the majority of herring schools detected during this survey were situated in regions north of 56ºN where there was a pool of water at 40 - 60m that was markedly cooler than all other areas (see Figures 3, 8 and 9). However bio-physical interactions in the region are likely to be complex and it was not possible to substantiate any robust correlations between temperature and herring distribution based on our data.

In 2012 there was a large influx of juvenile herring into the population, with approximately 42,300 t (10%) of the herring biomass and 608 million (23%) of the abundance attributed to 1-ringed fish. This influx is no longer evident in the 2013 survey data: only 11,100 t (9.3%) and 96.2 million (12.7%) individuals were 2-ringers. The good signal of an emerging year class noted last year did not materialise. In addition, no age 1 herring were sampled in the entire 2013 survey and the smallest sampled herring measured 21 cm, 4 cm longer than the smallest in 2012. This complete lack of young and small fish in the haul samples means that the survey does not seem to have successfully tracked cohorts this year.

4.2 Conclusions

- The northwest herring survey was completed successfully and robust estimates of herring abundance (757 mill.) and biomass (TSB 119k t) were calculated.
- There was a ~70% reduction in TSN, TSB, SSN and SSB from 2012. The true extent of the reduction will be apparent once these results are combined with those from the RV Scotia at the next WGIPS meeting.
- The majority of herring were distributed within ICES area VIaN and northern VIaS and very few herring schools were observed in VIIb.
- No age 1 herring were sampled in the entire survey and the survey did not successfully track the large influx of 1-ringers seen in 2012.
- CTD data indicated that coastal waters around northwest Ireland were warmer than those in the northern and shelf-break regions. The majority of herring seemed to be concentrated near a pool of cold water (< 10℃), 40-60m deep, west of Barra (between 8° and 9°) but in-depth analyses of the co rrelations between temperature and herring distribution were not performed.
- Twelve geographically spread herring hauls were sampled, using the SGHERWAY protocol, for later stock discrimination.
- Boarfish data was recorded and added to the coverage of the 2013 boarfish acoustic survey.
- A visual marine mammal and seabird survey was conducted.

5 Acknowledgements

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Table 1. Survey settings and calibration report (38kHz) for the Simrad ER60 echosounder. Northwest herring survey, June\July 2013.

```
# Calibration Version   2.1.0.12
#
# Date:  24/06/2013
#
# Location:
#   St John's Pt
#
# Reference Target:
#   TS               -33.50 dB       Min. Distance         15.00 m
#   TS Deviation       5.0 dB        Max. Distance         20.00 m
#
# Transducer:  ES38B  Serial No.   30227
#   Frequency          38000 Hz      Beamtype              Split
#   Gain              25.88 dB       Two Way Beam Angle   -20.6 dB
#   Athw. Angle Sens.      21.90      Along. Angle Sens.      21.90
#   Athw. Beam Angle     6.92 deg      Along. Beam Angle    6.87 deg
#   Athw. Offset Angle  -0.05 deg      Along. Offset Angle -0.06 deg
#   SaCorrection        -0.61 dB      Depth                8.80  m
#
# Transceiver:  GPT  38 kHz 009072033933 2-1 ES38B
#   Pulse Duration       1.024 ms      Sample Interval     0.192   m
#   Power               2000  W       Receiver Bandwidth   2.43 kHz
#
# Sounder Type:
#   EK60 Version  2.4.0
#
# TS Detection:
#   Min. Value         -50.0 dB       Min. Spacing          100 %
#   Max. Beam Comp.      6.0 dB       Min. Echolength        80 %
#   Max. Phase Dev.      8.0          Max. Echolength       180 %
#
# Environment:
#   Absorption Coeff.   8.2 dB/km      Sound Velocity     1496.6 m/s
#
# Beam Model results:
#   Transducer Gain    = 25.87 dB      SaCorrection       = -0.61 dB
#   Athw. Beam Angle   = 6.99 deg       Along. Beam Angle  = 6.98 deg
#   Athw. Offset Angle =-0.04 deg       Along. Offset Angle=-0.04 deg
#
# Data deviation from beam model:
#   RMS =    0.11 dB
#   Max =    0.29 dB  No. =   293  Athw. =  3.2 deg  Along =  3.3 deg
#   Min =   -0.51 dB  No. =   231  Athw. =  1.8 deg  Along = -4.6 deg
#
# Data deviation from polynomial model:
#   RMS =    0.07 dB
#   Max =    0.21 dB  No. =   118  Athw. =  2.2 deg  Along =  4.4 deg
#   Min =   -0.34 dB  No. =   119  Athw. =  2.0 deg  Along =  4.3 deg
```

Table 2. Catch composition and position of hauls undertaken by the RV *Celtic Explorer.* Northwest herring survey, June\July 2013. Latitude and longitude in decimal degrees.

No.	Date	Time	Lat. N	Lon. W	Target Depth (m)	Bottom Depth (m)	Bulk Catch (Kg)	Sampled Catch (Kg)	Herring %	Boarfish %	Mackerel %	Blue Whiting %	Others^ %
1	25/06/2013	23:13	57.708	6.479	10	78	0.5	0.5	0.0	0.0	0.0	0.0	100.0
2	26/06/2013	09:03	57.848	5.981	50	110	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	27/06/2013	04:01	58.391	6.808	35	45	200.0	200.0	92.6	0.0	7.4	0.0	0.0
4	28/06/2013	12:57	57.903	9.125	130	148	109.3	109.3	83.9	0.0	15.0	0.0	1.1
5	28/06/2013	20:09	57.643	8.742	150	155	234.8	234.8	90.0	0.0	10.0	0.0	0.0
6	29/06/2013	14:23	57.395	9.149	138	148	172.5	172.5	44.8	0.0	54.8	0.0	0.4
7	30/06/2013	10:15	56.888	8.617	115	133	342.7	309.7	98.7	0.0	0.2	0.0	1.1
8	01/07/2013	05:42	56.644	8.402	135	140	88.4	88.4	96.0	0.0	3.7	0.0	0.3
9	01/07/2013	12:27	56.520	9.023	140	145	1000.0	171.6	51.7	17.5	30.6	0.0	0.2
10	02/07/2013	19:10	56.268	7.028	60	65	18.7	18.7	0.8	0.3	0.0	0.0	98.9
11	03/07/2013	04:48	56.145	7.063	50	71	21.3	21.3	1.8	0.0	0.0	0.0	98.2
12	03/07/2013	10:08	56.144	8.157	97	107	94.1	94.1	0.3	0.0	99.5	0.0	0.2
13	03/07/2013	14:59	56.142	8.960	143	148	76.8	76.8	46.1	0.0	51.9	0.0	2.0
14	05/07/2013	10:29	55.767	7.519	40	50	750.0	144.7	99.4	0.0	0.5	0.0	0.1
15	06/07/2013	07:12	55.646	8.959	85	100	500.0	118.8	52.0	46.5	1.4	0.0	0.1
16	06/07/2013	15:25	55.518	8.584	70	85	18.7	18.7	21.3	0.7	59.4	0.0	18.6
17	07/07/2013	18:31	55.268	9.086	87	92	750.0	149.3	99.5	0.0	0.2	0.0	0.3
18	08/07/2013	05:25	55.142	8.814	68	78	750.0	150.6	100.0	0.0	0.0	0.0	0.0
19	08/07/2013	10:06	55.142	9.616	95	105	600.0	141.9	81.7	0.0	17.9	0.0	0.3
20	09/07/2013	04:36	54.894	9.638	89	93	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	09/07/2013	15:39	54.645	9.634	92	92	18.4	18.4	26.1	0.0	2.2	0.7	71.0
22	11/07/2013	08:08	53.648	10.834	135	145	260.2	260.2	2.5	0.0	1.4	94.4	1.7

Table 3. Length-frequency of herring hauls used in the analysis. Northwest herring survey, June\July 2013.

Length (cm)	Haul 3	Haul 4	Haul 5	Haul 7	Haul 8	Haul 14	Haul 17	Haul 18	Haul 19	Haul 21
15	-	-	-	-	-	-	-	-	-	-
15.5	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-
16.5	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-
17.5	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-
18.5	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-
19.5	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-
20.5	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	1	-	-	-	-
21.5	-	-	-	-	-	1	-	-	-	-
22	-	-	-	-	-	5	-	-	-	-
22.5	1	-	-	-	-	24	1	1	-	-
23	3	-	-	-	-	26	5	2	-	-
23.5	6	-	-	1	3	21	10	2	-	-
24	9	1	1	5	7	12	13	4	-	-
24.5	9	1	1	9	15	6	15	6	1	12
25	11	1	3	13	21	3	13	9	2	-
25.5	9	5	5	12	15	1	11	11	6	16
26	4	6	3	11	9	-	10	14	17	22
26.5	6	3	7	9	7	-	4	19	14	6
27	7	9	10	11	4	-	7	10	18	22
27.5	8	15	10	10	3	-	7	10	15	19
28	11	19	17	6	6	-	2	8	14	-
28.5	7	20	22	7	5	-	1	2	8	3
29	5	10	11	2	3	-	1	2	3	-
29.5	3	6	8	3	-	-	-	1	2	-
30	1	3	-	-	-	-	-	1	-	-
30.5	1	-	1	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-	-	-
31.5	-	-	-	-	-	-	-	-	-	-
32	-	-	-	-	-	-	-	-	-	-
32.5	-	-	-	-	-	-	-	-	-	-
Division	**VIaN**	**VIaN**	**VIaN**	**VIaN**	**VIaN**	**VIaS**	**VIaS**	**VIaS**	**VIaS**	**VIaS**

Table 4. Herring length at age (winter rings) as abundance (millions) and biomass (000's tonnes). Northwest herring survey, June\July 2013.

Length (cm)	Age 0	(rings) 1	2	3	4	5	6	7	8	9	10	Abund. (mill.s)	Biomass '000's tonnes	Mn Wt (g)
21	-	-	0.49	-	-	-	-	-	-	-	-	0.49	0.04	85
21.5	-	-	0.49	-	-	-	-	-	-	-	-	0.49	0.04	90.4
22	-	-	2.68	0.33	-	-	-	-	-	-	-	3.02	0.29	96.1
22.5	-	-	16.07	-	-	-	-	-	-	-	-	16.07	1.64	102
23	-	-	18.26	2.28	0.57	-	-	-	-	-	-	21.11	2.28	108.2
23.5	-	-	19.83	7.04	-	-	-	-	-	-	-	26.87	3.08	114.5
24	-	-	17.46	17.88	-	-	-	-	-	-	-	35.34	4.28	121.1
24.5	-	-	11.57	38.37	0.81	-	-	-	-	-	-	50.75	6.49	127.9
25	-	-	5.48	52.37	3.04	-	-	-	-	-	-	60.89	8.22	135
25.5	-	-	2.93	53.49	8.26	0.39	-	-	-	-	-	65.07	9.26	142.2
26	-	-	-	39.27	27.32	3.98	0.57	-	-	-	-	71.14	10.66	149.8
26.5	-	-	0.43	25.45	30.35	4.89	-	-	-	-	-	61.12	9.63	157.6
27	-	-	-	9.06	49.19	12.85	2.15	1.04	-	-	-	74.3	12.3	165.6
27.5	-	-	-	6.74	48.42	11.62	2.73	1.36	0.43	0.43	-	71.73	12.47	173.9
28	-	-	-	1.49	48.33	14.15	3.4	2.9	0.5	-	-	70.77	12.91	182.4
28.5	-	-	-	0.51	38.01	14.6	6.3	1.93	1.93	0.51	0.51	64.32	12.3	191.2
29	-	-	-	-	8.21	10.95	6.83	3.64	1.82	0.45	-	31.9	6.39	200.2
29.5	-	-	-	-	3.85	4.49	3.85	3.85	3.54	1.29	0.32	21.19	4.44	209.6
30	-	-	-	-	-	0.73	1.09	2.18	1.46	1.46	-	6.92	1.52	219.1
30.5	-	-	-	-	-	-	-	1.56	0.78	-	0.39	2.72	0.62	229
31	-	-	-	-	-	-	-	-	0.25	-	-	0.25	0.06	239.1
31.5	-	-	-	-	-	-	-	-	0.14	-	-	0.14	0.03	249.5
SSN	-	-	94.41	254.3	266.4	78.68	26.93	18.47	10.7	4.14	1.22	755.26	-	-
SSB	-	-	10.92	35.78	45.73	14.24	5.157	3.679	2.198	0.853	0.254	-	118.811	-
Mn Weight	-	-	115.4	140.7	171.6	181	191.5	199.2	205.9	205.9	208	-	-	-
Mn Length	-	-	23.8	25.6	27.6	28.1	28.7	29.2	29.5	29.5	29.6	-	-	-

Table 5. Herring biomass (000's tonnes) at age (winter rings) by ICES statistical rectangle and division. Northwest herring survey, June\July 2013.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
45E4	0	0	0	0	0	0	0	0	0	0	0	0
45E3	0	0	0.2	0.6	0.7	0.2	0.1	0.1	0	0	0	1.9
45E2	0	0	1.2	3.1	3.2	1.1	0.4	0.3	0.2	0.1	0	9.6
45E1	0	0	0.1	0.4	0.7	0.2	0.1	0.1	0	0	0	1.6
45E0	0	0	0	0	0.1	0	0	0	0	0	0	0.1
44E4	0	0	0	0	0	0	0	0	0	0	0	0
44E3	0	0	0	0	0	0	0	0	0	0	0	0
44E2	0	0	0	0	0	0	0	0	0	0	0	0
44E1	0	0	0.1	0.9	3.4	1.3	0.6	0.4	0.3	0.1	0	7.1
44E0	0	0	0	0.6	2.6	1	0.4	0.3	0.2	0.1	0	5.2
43E3	0	0	0	0	0	0	0	0	0	0	0	0
43E2	0	0	0	0	0.2	0.1	0	0	0	0	0	0.3
43E1	0	0	0	0.6	2.7	1.1	0.5	0.4	0.3	0.1	0	5.7
43E0	0	0	0	0.6	3.7	1.6	0.8	0.6	0.4	0.2	0	7.9
42E3	0	0	0	0	0	0	0	0	0	0	0	0
42E2	0	0	0.2	1.1	0.6	0.2	0.1	0	0	0	0	2.2
42E1	0	0	1.3	8.5	7.6	2.2	0.8	0.5	0.3	0.1	0	21.3
42E0	0	0	0	0.3	0.3	0.1	0	0	0	0	0	0.7
41E3	0	0	0	0	0	0	0	0	0	0	0	0
41E2	0	0	0.2	0.1	0	0	0	0	0	0	0	0.3
41E1	0	0	1.5	3.2	1.5	0.4	0.1	0.1	0	0	0	6.8
41E0	0	0	0.1	0.7	0.4	0.1	0	0	0	0	0	1.3
40E3	0	0	0.3	0.1	0	0	0	0	0	0	0	0.4
40E2	0	0	2.8	1	0.1	0	0	0	0	0	0	3.9
40E1	0	0	1.3	2.3	1.1	0.3	0.1	0	0	0	0	5.1
40E0	0	0	0.1	0.5	0.3	0.1	0	0	0	0	0	1
39E2	0	0	0	0	0	0	0	0	0	0	0	0
39E1	0	0	0.6	2.6	2.3	0.6	0.1	0.1	0.1	0	0	6.4
39E0	0	0	0.5	2.2	2.8	0.7	0.2	0.1	0.1	0	0	6.6
39D9	0	0	0	0	0	0	0	0	0	0	0	0
38E1	0	0	0	0	0	0	0	0	0	0	0	0
38E0	0	0	0.1	4.9	10	2.7	0.7	0.5	0.2	0.1	0	19.2
38D9	0	0	0	0	0	0	0	0	0	0	0	0
37E1	0	0	0.1	0.7	0.9	0.2	0	0	0	0	0	1.9
37E0	0	0	0	0.5	0.5	0.1	0	0	0	0	0	1.1
37D9	0	0	0	0	0.1	0	0	0	0	0	0	0.1
36D9	0	0	0	0.1	0.1	0	0	0	0	0	0	0.2
36D8	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**11.1**	**35.7**	**45.6**	**14.2**	**5.2**	**3.7**	**2.2**	**0.9**	**0.3**	**118.9**
%	**0**	**0**	**9.3**	**30.1**	**38.4**	**12.0**	**4.3**	**3.1**	**1.9**	**0.7**	**0**	**100**

VIaN	0	0	5.6	20.9	27.4	9.5	4.1	3	1.8	0.8	0.3	73.4
VIaS	0	0	5.4	13.5	16.6	4.4	1.1	0.7	0.4	0.1	0	42.2
VIIb	0	0	0.1	1.3	1.6	0.3	0	0	0	0	0	3.3

Table 6. Herring abundance (millions) at age (winter rings), by ICES statistical rectangle and division. Northwest herring survey, June\July 2013.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
45E4	0	0	0	0	0	0	0	0	0	0	0	0
45E3	0	0	2.08	4.59	3.78	1.2	0.45	0.34	0.19	0.07	0.02	12.7
45E2	0	0	10.2	22.6	18.6	5.91	2.19	1.67	0.94	0.35	0.12	62.6
45E1	0	0	1.01	2.76	3.92	1.35	0.53	0.38	0.24	0.09	0.02	10.3
45E0	0	0	0.01	0.16	0.56	0.21	0.09	0.06	0.04	0.02	0	1.14
44E4	0	0	0	0	0	0	0	0	0	0	0	0
44E3	0	0	0	0	0	0	0	0	0	0	0	0
44E2	0	0	0.04	0.1	0.11	0.04	0.01	0.01	0.01	0	0	0.32
44E1	0	0	0.61	6.15	18.7	7.05	2.96	1.96	1.38	0.39	0.16	39.3
44E0	0	0	0.27	4.14	14.5	5.31	2.2	1.51	1.01	0.4	0.09	29.4
43E3	0	0	0	0	0	0	0	0	0	0	0	0
43E2	0	0	0.03	0.29	0.89	0.34	0.14	0.09	0.07	0.02	0.01	1.87
43E1	0	0	0.37	4.19	14.9	5.8	2.54	1.84	1.24	0.44	0.14	31.5
43E0	0	0	0.21	4.01	20.3	8.24	3.81	3.13	1.98	0.9	0.23	42.8
42E3	0	0	0	0	0	0	0	0	0	0	0	0
42E2	0	0	1.85	8.26	3.44	0.87	0.27	0.18	0.09	0.03	0.02	15
42E1	0	0	10.6	61.1	45.1	12.2	3.95	2.56	1.54	0.62	0.15	138
42E0	0	0	0.32	2.01	1.65	0.44	0.14	0.09	0.05	0.02	0.01	4.72
41E3	0	0	0	0	0	0	0	0	0	0	0	0
41E2	0	0	1.86	0.71	0.1	0.02	0.01	0	0	0	0	2.7
41E1	0	0	13.3	23.9	8.99	2.26	0.71	0.47	0.24	0.08	0.04	50
41E0	0	0	1.14	5.12	2.13	0.54	0.17	0.11	0.06	0.02	0.01	9.29
40E3	0	0	2.64	0.79	0.04	0.01	0	0	0	0	0	3.47
40E2	0	0	26.3	7.88	0.35	0.05	0.01	0	0	0	0	34.6
40E1	0	0	11.4	17.3	6.71	1.5	0.35	0.17	0.06	0.02	0	37.5
40E0	0	0	0.99	3.35	1.7	0.36	0.08	0.04	0.01	0.01	0	6.53
39E2	0	0	0	0	0	0	0	0	0	0	0	0
39E1	0	0	5.03	18.2	14.1	3.27	0.78	0.58	0.26	0.14	0.02	42.4
39E0	0	0	3.99	15.1	16.6	4.2	1.1	0.67	0.29	0.11	0.04	42.1
39D9	0	0	0	0	0	0	0	0	0	0	0	0
38E1	0	0	0	0	0	0	0	0	0	0	0	0
38E0	0	0	1.08	32.3	59.3	15.4	4.06	2.44	1.09	0.39	0.14	116
38D9	0	0	0	0	0	0	0	0	0	0	0	0
37E1	0	0	0.45	5.14	5.3	1.16	0.23	0.09	0.03	0.02	0	12.4
37E0	0	0	0.28	3.25	3.34	0.73	0.14	0.06	0.02	0.01	0	7.83
37D9	0	0	0.03	0.31	0.31	0.07	0.01	0.01	0	0	0	0.74
36D9	0	0	0.13	0.66	0.37	0.08	0.02	0.01	0	0	0	1.27
36D8	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**96.2**	**254**	**266**	**78.7**	**26.9**	**18.5**	**10.8**	**4.14**	**1.22**	**757**
%	**0**	**0**	**12.7**	**33.6**	**35.1**	**10.4**	**3.56**	**2.44**	**1.43**	**0.55**	**0.16**	**100**
Cv (%)	**-**	**-**	**22.2**	**21.1**	**25.4**	**24.3**	**22.9**	**22**	**21.9**	**20.4**	**22.6**	**-**

VIaN	0	0	46.5	151	158	51.8	20.2	14.4	9.08	3.45	1.01	455
VIaS	0	0	48.8	94.2	98.8	24.8	6.37	3.9	1.71	0.67	0.21	279
VIIb	0	0	0.89	9.35	9.32	2.04	0.4	0.17	0.05	0.03	0.01	22.3

Table 7. Herring biomass (000's tonnes) at maturity by ICES statistical rectangle and division. Northwest herring survey, June\July 2013.

Strata	Immature	Mature	Spent	Total
45E4	0	0	0	0
45E3	0.5	0.4	1	2
45E2	2.7	1.9	5	9.7
45E1	0.3	0.4	1	1.7
45E0	0	0	0.1	0.2
44E4	0	0	0	0
44E3	0	0	0	0
44E2	0	0	0	0.1
44E1	0.4	1.7	5	7
44E0	0.2	1.2	3.8	5.3
43E3	0	0	0	0
43E2	0	0.1	0.2	0.3
43E1	0.2	1.3	4.1	5.7
43E0	0.2	1.8	5.9	7.9
42E3	0	0	0	0
42E2	0.8	0.4	1	2.2
42E1	5.2	4.6	11.7	21.4
42E0	0.2	0.2	0.4	0.7
41E3	0	0	0	0
41E2	0.3	0	0	0.3
41E1	3.2	1.2	2.6	6.9
41E0	0.5	0.3	0.6	1.4
40E3	0.3	0	0	0.4
40E2	3.5	0.2	0.2	3.8
40E1	2.5	0.8	1.8	5.1
40E0	0.3	0.2	0.4	0.9
39E2	0	0	0	0
39E1	1.6	1.3	3.5	6.4
39E0	1.3	1.4	3.8	6.6
39D9	0	0	0	0
38E1	0	0	0	0
38E0	1.5	4.6	13.2	19.3
38D9	0	0	0	0
37E1	0.3	0.4	1.2	1.9
37E0	0.2	0.3	0.7	1.2
37D9	0	0	0.1	0.1
36D9	0.1	0	0.1	0.2
36D8	0	0	0	0
Total	**26.3**	**24.8**	**67.8**	**118.9**
%	**22.1**	**20.8**	**57**	**100**

VIaN	15	15.6	42.8	73.4
VIaS	10.7	8.5	22.9	42.1
VIIb	0.6	0.7	2.1	3.4

Table 8. Herring abundance (millions) at maturity by ICES statistical rectangle and division. Northwest herring survey, June\July 2013.

Strata	Immature	Mature	Spent	Total
45E4	0	0	0	0
45E3	6.042	2.822	6.13	14.994
45E2	0	0	0	0
45E1	0.13	0.439	1.299	1.868
45E0	0	0	0	0
44E4	0	0	0	0
44E3	4.385	2.388	5.948	12.721
44E2	0	0	0	0
44E1	21.594	11.758	29.294	62.647
44E0	2.284	2.142	5.877	10.303
43E3	0.059	0.268	0.809	1.135
43E2	0.089	0.063	0.165	0.317
43E1	2.717	9.249	27.373	39.339
43E0	1.568	6.936	20.931	29.435
42E3	1.718	7.383	22.395	31.496
42E2	1.282	9.974	31.502	42.758
42E1	38.826	28.545	70.412	137.783
42E0	1.221	0.995	2.501	4.717
41E3	3.744	1.749	3.799	9.291
41E2	25.829	7.723	16.411	49.963
41E1	2.305	0.149	0.245	2.699
41E0	0	0	0	0
40E3	2.577	1.189	2.76	6.527
40E2	20.608	5.338	11.575	37.521
40E1	31.503	1.315	1.734	34.551
40E0	3.162	0.132	0.174	3.468
39E2	0	0	0	0
39E1	10.108	8.719	23.239	42.065
39E0	12.732	8.383	21.333	42.449
39D9	0	0	0	0
38E1	0	0	0	0
38E0	10.296	27.491	78.511	116.298
38D9	0	0	0	0
37E1	0.148	0.158	0.43	0.736
37E0	1.571	1.685	4.577	7.833
37D9	2.49	2.671	7.256	12.417
36D9	0	0	0	0
36D8	0.431	0.247	0.586	1.265
Total	**209.417**	**149.91**	**397.268**	**756.595**
%	**27.679**	**19.814**	**52.507**	**100**

VIaN	116.368	93.771	247.853	457.992
VIaS	88.409	51.378	136.566	276.352
VIIb	4.64	4.761	12.849	22.251

Table 9. Herring biomass and abundance by ICES statistical rectangle. Northwest herring survey, June\July 2013.

Stratum	No. Transects	No. Schools	Def Schools	Mix Schools	Prob. Schools	% zeros	Def. Bio.	Mix Bio.	Prob. Bio.	Biomass ('000's t)	SSB ('000's t)	Abund (mills.)
45E4	3	0	0	0	0	100	0	0	0	0	0	0
45E3	5	8	8	0	0	80	2	0	0	2	1.4	12.721
45E2	2	24	15	0	9	50	9.3	0	0.4	9.7	7	62.647
45E1	2	26	14	0	12	0	1	0	0.7	1.7	1.4	10.303
45E0	1	3	0	0	3	0	0	0	0.2	0.2	0.2	1.135
44E4	2	0	0	0	0	100	0	0	0	0	0	0
44E3	6	0	0	0	0	100	0	0	0	0	0	0
44E2	2	2	0	0	2	50	0	0	0.1	0.1	0	0.317
44E1	2	53	42	0	11	0	6.5	0	0.5	7	6.7	39.339
44E0	2	19	5	0	14	0	2.4	0	2.9	5.3	5.1	29.435
43E3	5	0	0	0	0	100	0	0	0	0	0	0
43E2	6	1	0	0	1	83	0	0	0.3	0.3	0.3	1.868
43E1	2	57	0	34	23	0	0	2.1	3.6	5.7	5.5	31.496
43E0	2	22	0	21	1	0	0	7.6	0.3	7.9	7.7	42.758
42E3	3	0	0	0	0	100	0	0	0	0	0	0
42E2	6	21	0	0	21	83	0	0	2.2	2.2	1.4	14.994
42E1	4	115	80	26	9	0	20	1	0.4	21.4	16.3	137.783
42E0	4	3	3	0	0	75	0.7	0	0	0.7	0.6	4.717
41E3	3	0	0	0	0	100	0	0	0	0	0	0
41E2	4	6	0	0	6	50	0	0	0.3	0.3	0.1	2.699
41E1	4	83	7	0	76	0	0.5	0	6.4	6.9	3.8	49.963
41E0	4	1	0	0	1	75	0	0	1.4	1.4	0.9	9.291
40E3	3	3	0	0	3	33	0	0	0.4	0.4	0	3.468
40E2	4	17	9	0	8	0	3.4	0	0.5	3.8	0.4	34.551
40E1	4	32	13	8	11	0	4.3	0.4	0.5	5.1	2.6	37.521
40E0	4	16	0	12	4	25	0	0.6	0.3	0.9	0.6	6.527
39E2	2	0	0	0	0	100	0	0	0	0	0	0
39E1	4	29	21	0	8	0	6.2	0	0.3	6.4	4.8	42.449
39E0	4	57	41	0	16	0	5.2	0	1.4	6.6	5.3	42.065
39D9	1	0	0	0	0	100	0	0	0	0	0	0
38E1	2	0	0	0	0	100	0	0	0	0	0	0
38E0	2	29	29	0	0	0	19.3	0	0	19.3	17.8	116.298
38D9	2	0	0	0	0	100	0	0	0	0	0	0
37E1	1	9	0	0	9	0	0	0	1.9	1.9	1.6	12.417
37E0	1	11	0	0	11	0	0	0	1.2	1.2	1	7.833
37D9	2	3	0	0	3	50	0	0	0.1	0.1	0.1	0.736
36D9	2	4	0	4	0	50	0	0.2	0	0.2	0.1	1.265
36D8	2	0	0	0	0	100	0	0	0	0	0	0
Total	**114**	**654**	**287**	**105**	**262**	**52**	**80.7**	**11.9**	**26.3**	**118.9**	**92.7**	**756.595**
Cv (%)	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**21.5**	**23.5**	**21**

Table 10. Historic survey time-series for areas VIaS and VIIb. Abundance (millions), TSB and SSB (tonnes), age in winter rings. Northwest herring survey, June\July 2013.

Winter rings	2008	2009	2010	2011	2012	2013
0	-	-	-	-	-	-
1	6.1	416.4	16.5	44.6	25.9	-
2	75.9	81.3	292.8	86.3	360.9	49.7
3	64.7	11.4	85.2	146.8	92.8	103.5
4	38.4	15.1	63.2	28.9	42.9	108.1
5	22.3	7.7	43.2	5.7	8.0	26.9
6	26.2	7.1	27.3	4.3	3.7	6.8
7	9.1	7.5	19.0	4.8	3.5	4.1
8	5.0	0.4	12.5	2.1	2.1	1.8
9	3.7	0.9	5.5	1.4	1.3	0.7
10+	-	-	-	0.8	1.1	0.2
TSN (mil)	251.4	547.7	565.2	325.7	542.2	301.7
TSB (t)	44,611	46,460	82,100	40,700	68,300	45,500
SSB (t)	43,006	20,906	81,400	28,600	42,600	34,300
CV	34.2	32.2	-	-	-	-

Survey coverage: VIaS & VIIb

Table 11. Historic survey time-series for all areas surveyed. Abundance (millions), TSB and SSB (tonnes), age in winter rings. Northwest herring survey, June\July 2013. Note that the 2011-2013 survey coverage in VIaN was much greater than that in 2010.

Winter rings	2008^	2009^	2010*	2011*	2012*	2013*
0	-	-	-	-	-	-
1	6.1	416.4	524.8	82.1	608.3	-
2	75.9	81.3	504.3	202.5	451.5	96.2
3	64.7	11.4	133.3	752.0	444.6	254.3
4	38.4	15.1	107.4	381.0	516.1	265.8
5	22.3	7.7	103.0	110.8	180.3	78.7
6	26.2	7.1	83.7	124.0	115.4	26.9
7	9.1	7.5	57.6	118.4	116.9	18.5
8	5.0	0.4	35.3	70.7	83.8	10.8
9	3.7	0.9	17.5	41.6	56.3	4.1
10+	-	-	-	25.6	42.0	1.2
TSN (mil)	251.4	547.7	1,566.9	1,908.7	2,615.0	756.6
TSB (t)	44,611	46,460	192,979	313,305	397,797	118,946
SSB (t)	43,006	20,906	170,154	284,632	325,835	92,700
CV	34.2	32.2	24.7	22.4	22.8	21.5

^ Survey coverage: VIaS & VIIb

* Survey coverage: VIaS, VIaN & VIIb

Table 12. Sightings, counts, and group size ranges of cetaceans. Northwest herring survey, June\July 2013. Includes species seen outside observer hours or +6 sea state.

Species	No. of Sightings	No. of Individuals	Range of Group Size
Common dolphin	15	114	4-40
Atlantic white-sided dolphin	5	21	2-5
Harbour porpoise	5	10	1-3
Minke Whale	5	5	1
Risso's dolphin	2	6	1-5
White beaked dolphin	1	5	5
Killer Whale	1	4	4
Bottlenose dolphin	1	4	4
Basking shark	2	2	1
Grey seal	7	7	1
Common seal	4	4	1
Unidentified dolphin	9	40	-
Unidentified whale	1	1	-
Sunfish	3	3	1

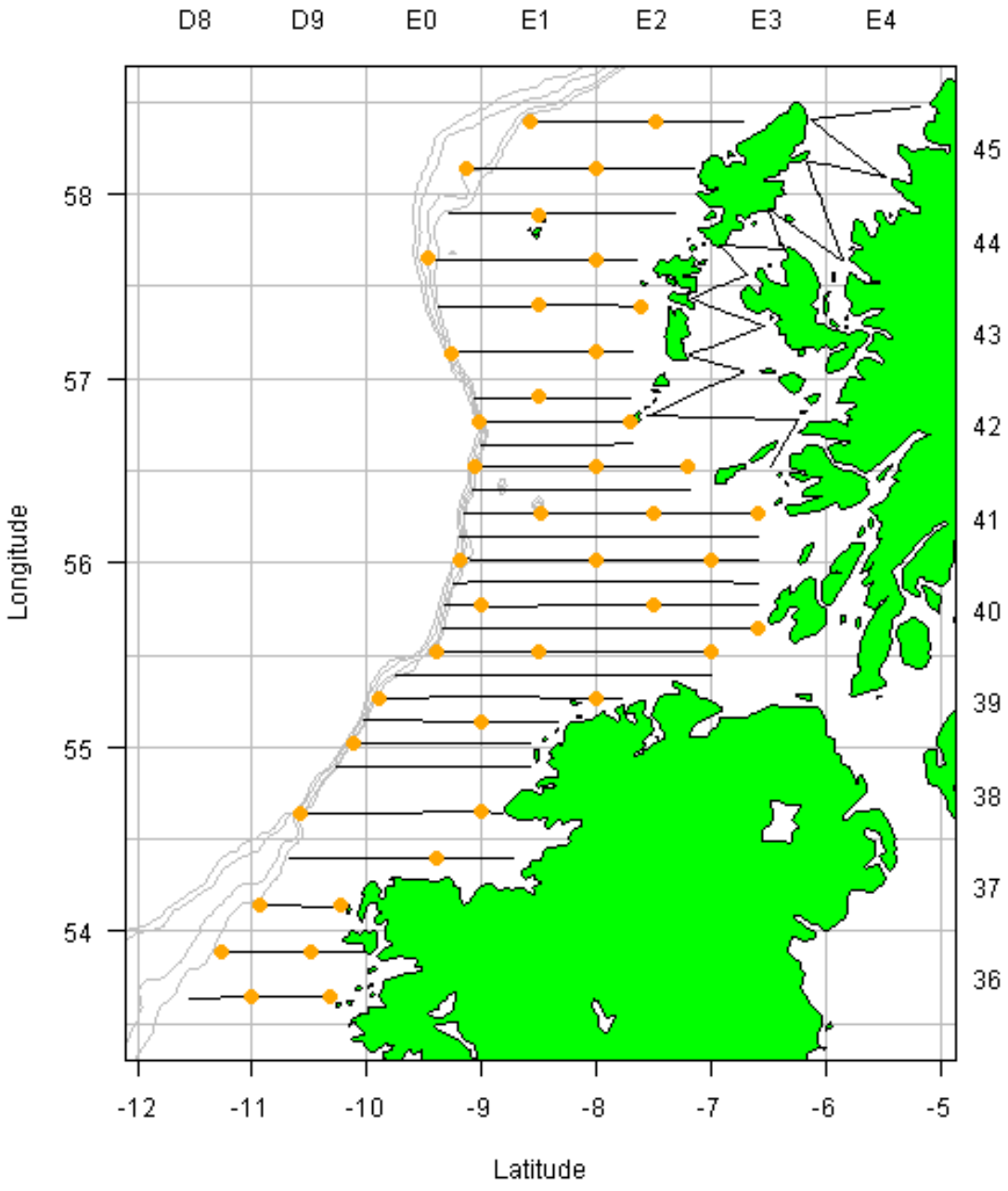


Figure 1. RV Celtic Explorer cruise track during the Northwest herring survey, June\July 2013 (excluding inter-transect segments). Orange circles are hydrographic stations.

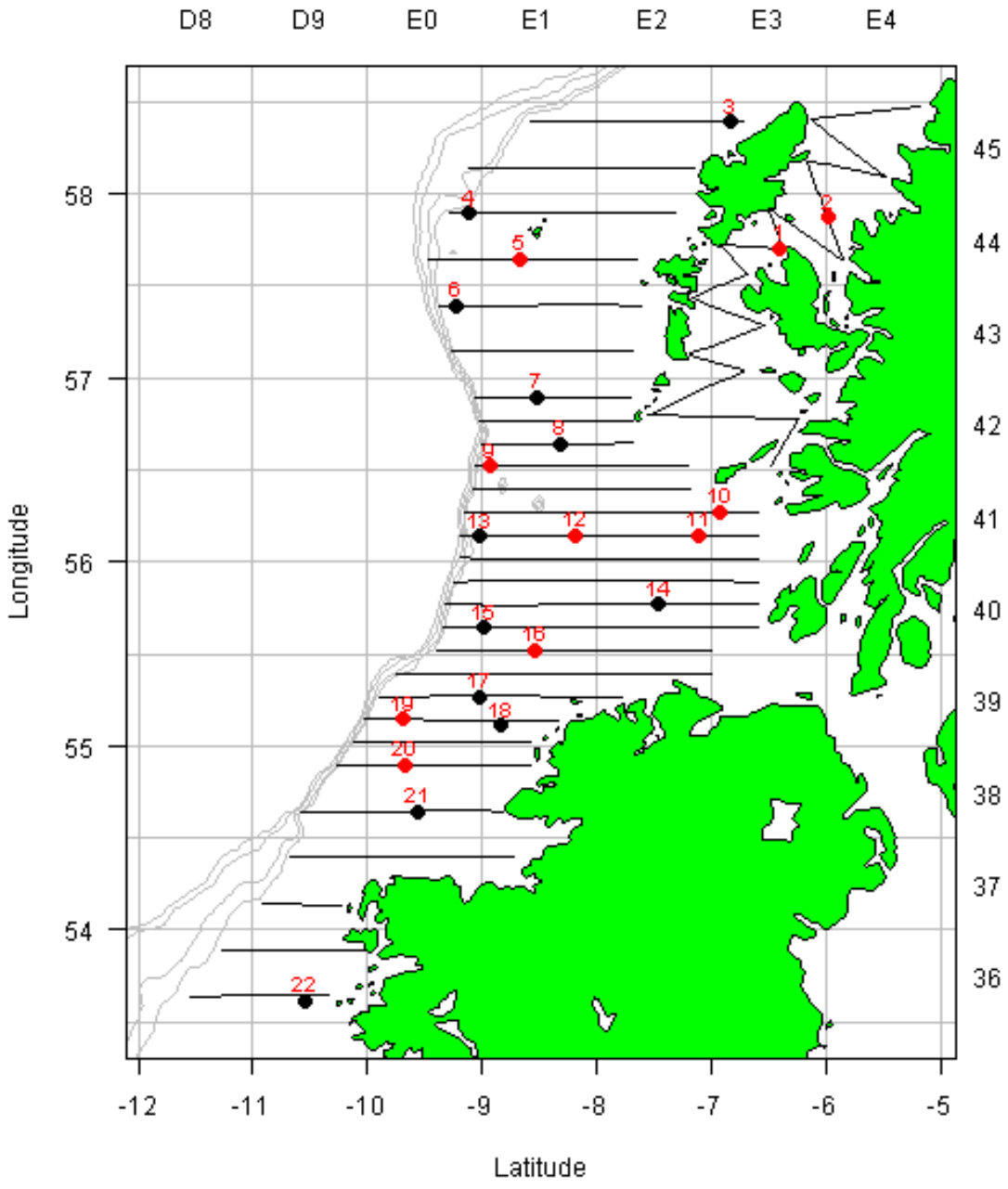


Figure 2. RV Celtic Explorer fishing trawl stations. Northwest herring survey, June\July 2013. SGHERWAY sampled hauls are indicated in black.

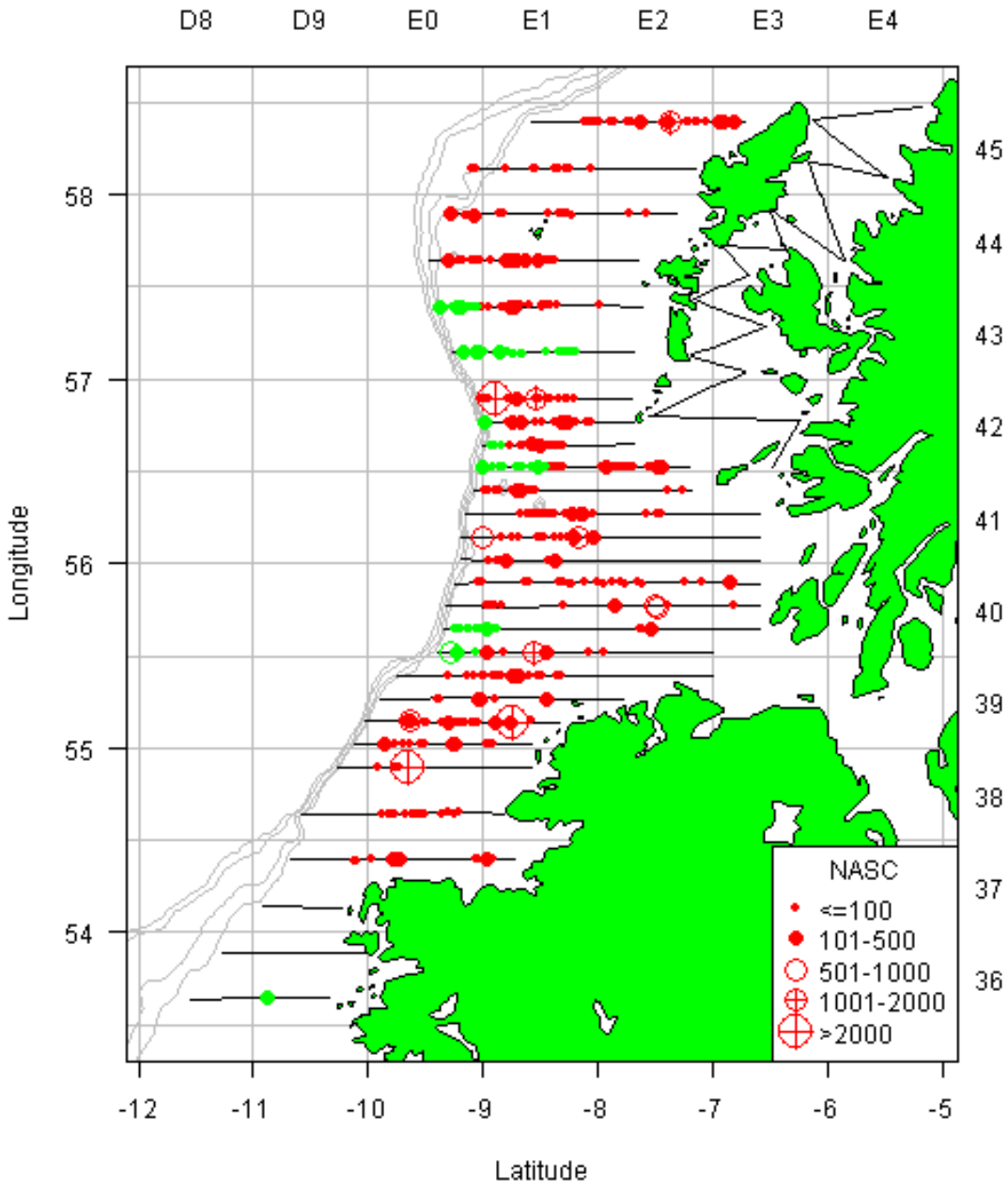


Figure 3. NASC plot of herring distribution during the 2013 survey. Red circles represent single herring schools (“definitely” and “probably” herring categories). Green circles represent herring occurring in mixed schools.

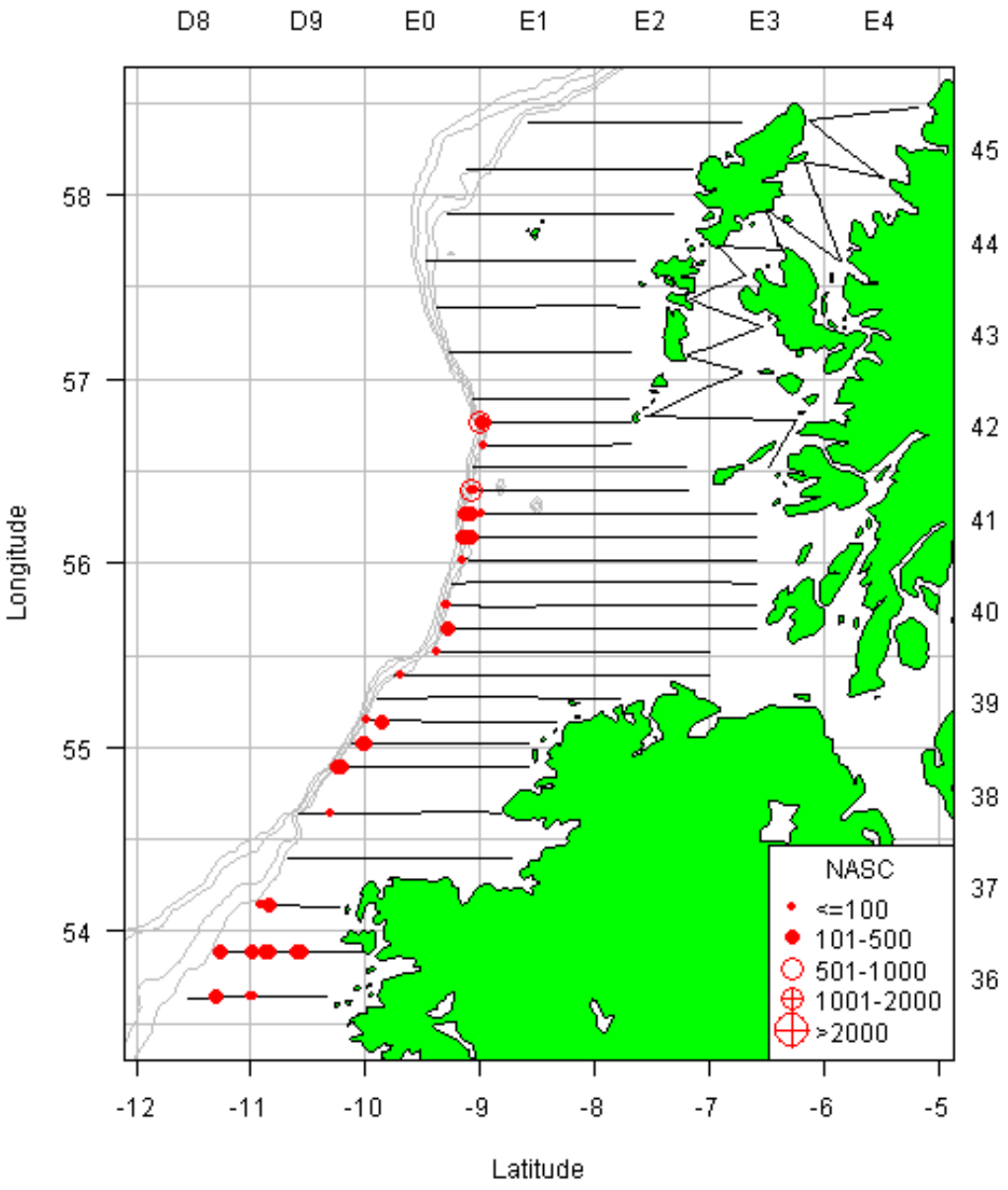


Figure 4. NASC plot of boarfish (*Capros aper*) distribution during the 2013 Northwest herring survey.

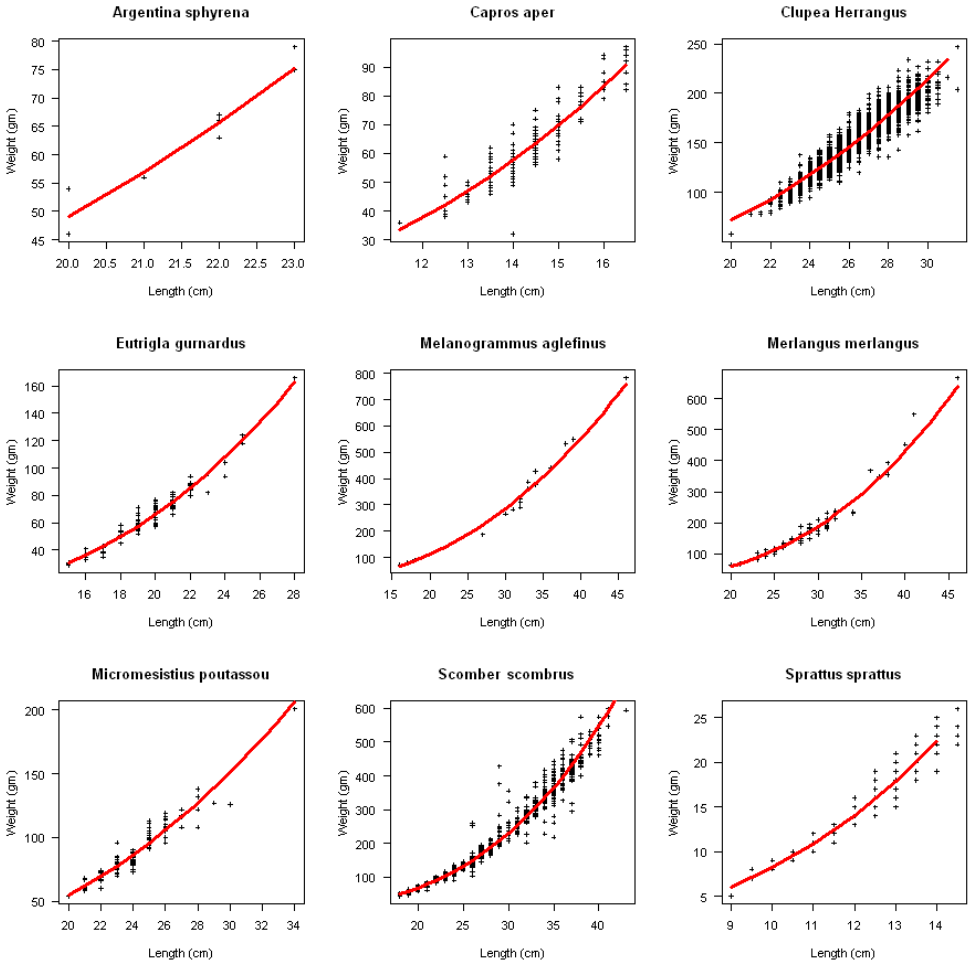


Figure 5. Length-weight plots of major species encountered during the Northwest herring acoustic survey, June\July 2012.

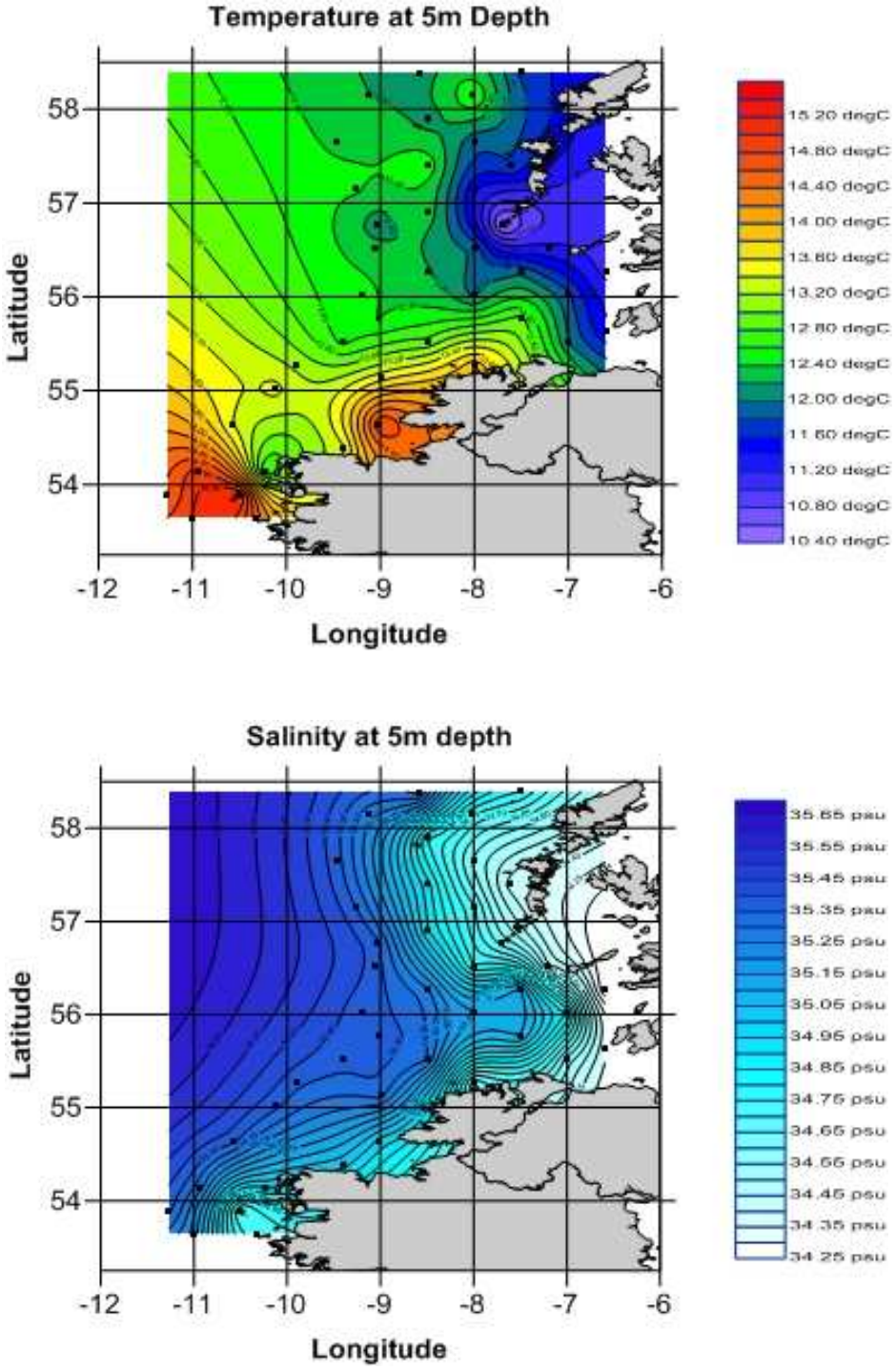


Figure 6. Horizontal temperature (top panel) and salinity (bottom panel) at 5m subsurface as derived from vertical CTD cast data (black squares). Northwest herring survey, June/July 2013.

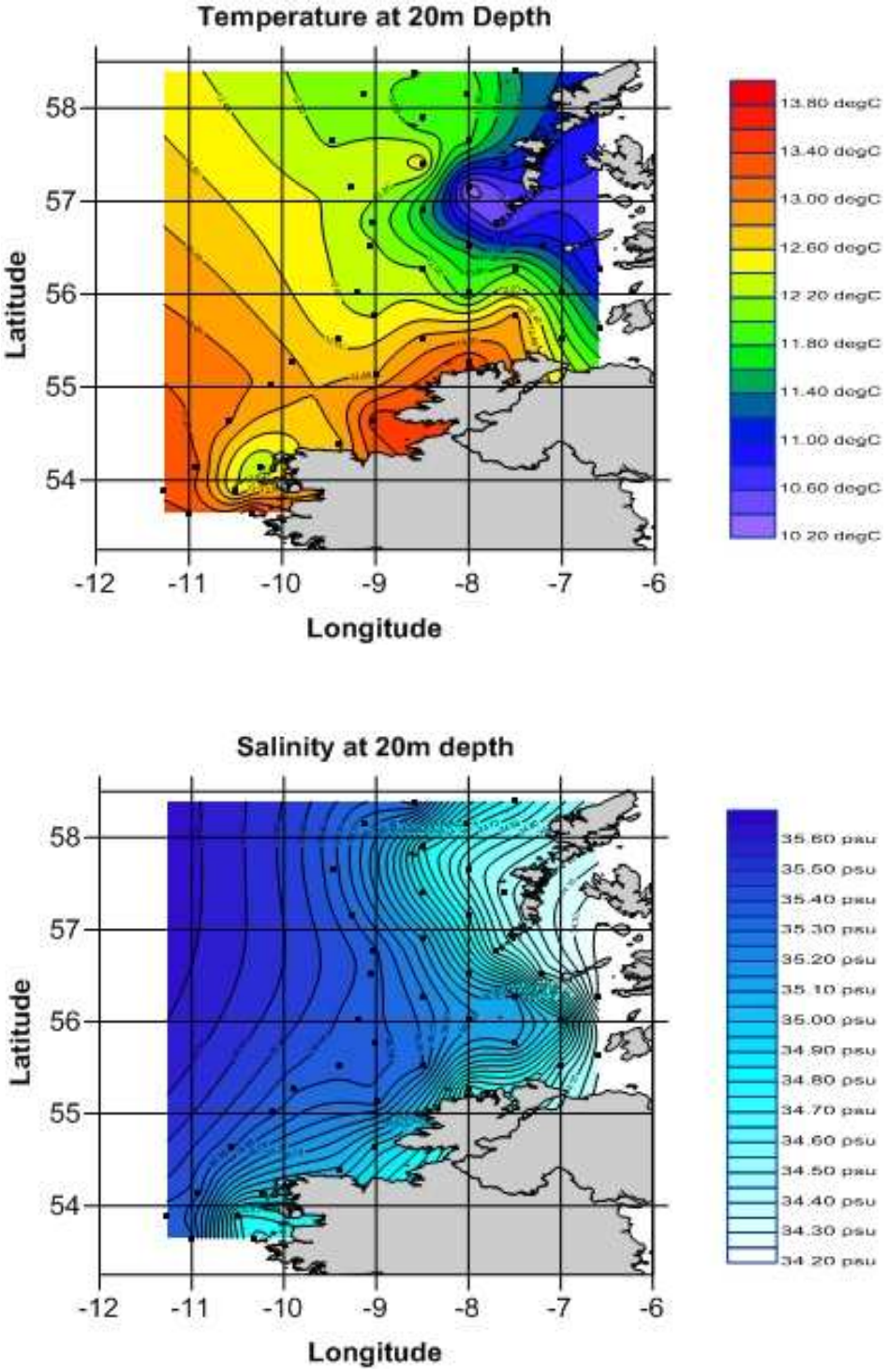


Figure 7. Horizontal temperature (top panel) and salinity (bottom panel) at 20m subsurface as derived from vertical CTD cast data (black squares). Northwest herring survey, June/July 2013.

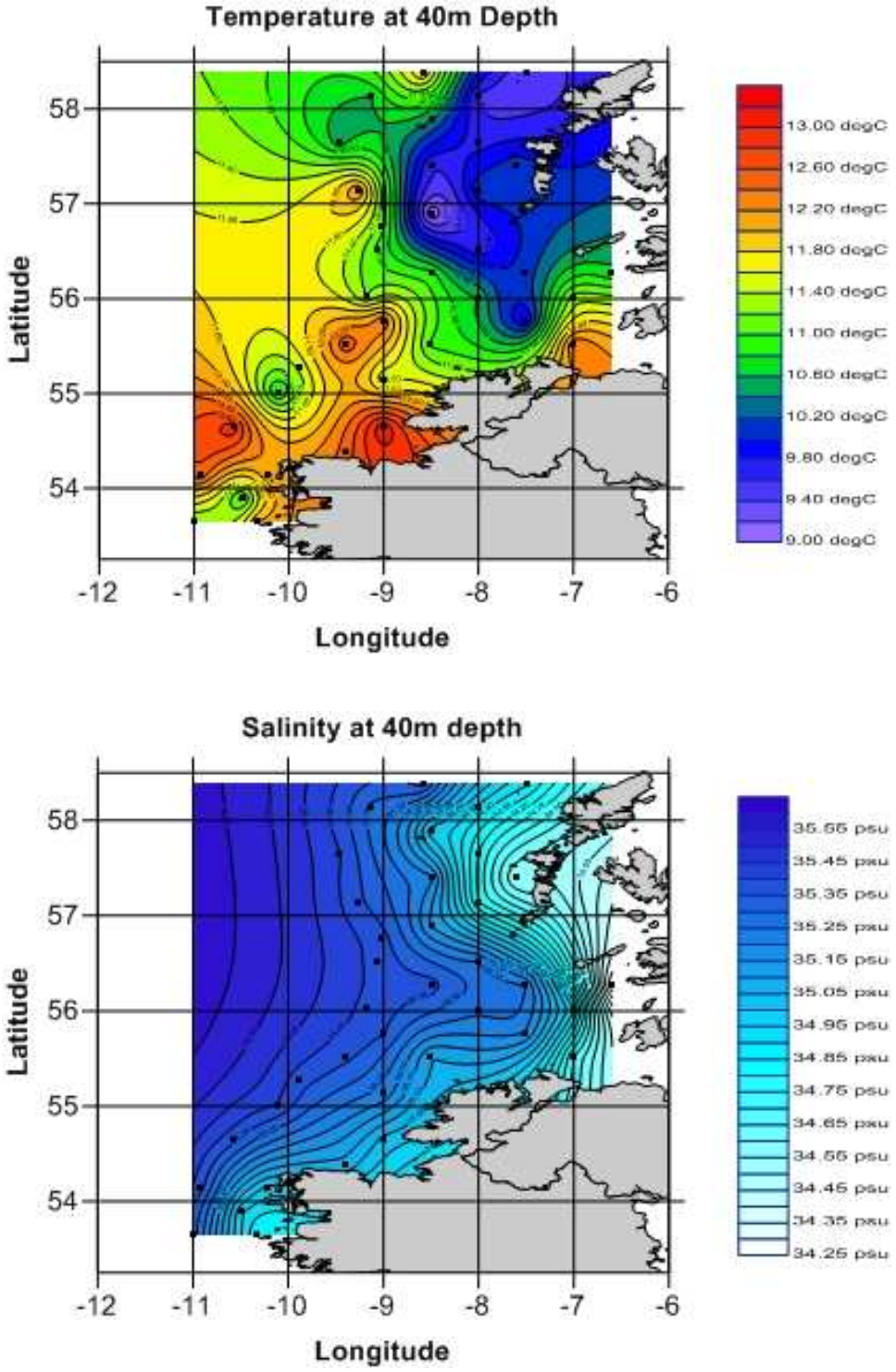


Figure 8. Horizontal temperature (top panel) and salinity (bottom panel) at 40m subsurface as derived from vertical CTD cast data (black squares). Northwest herring survey, June/July 2013.

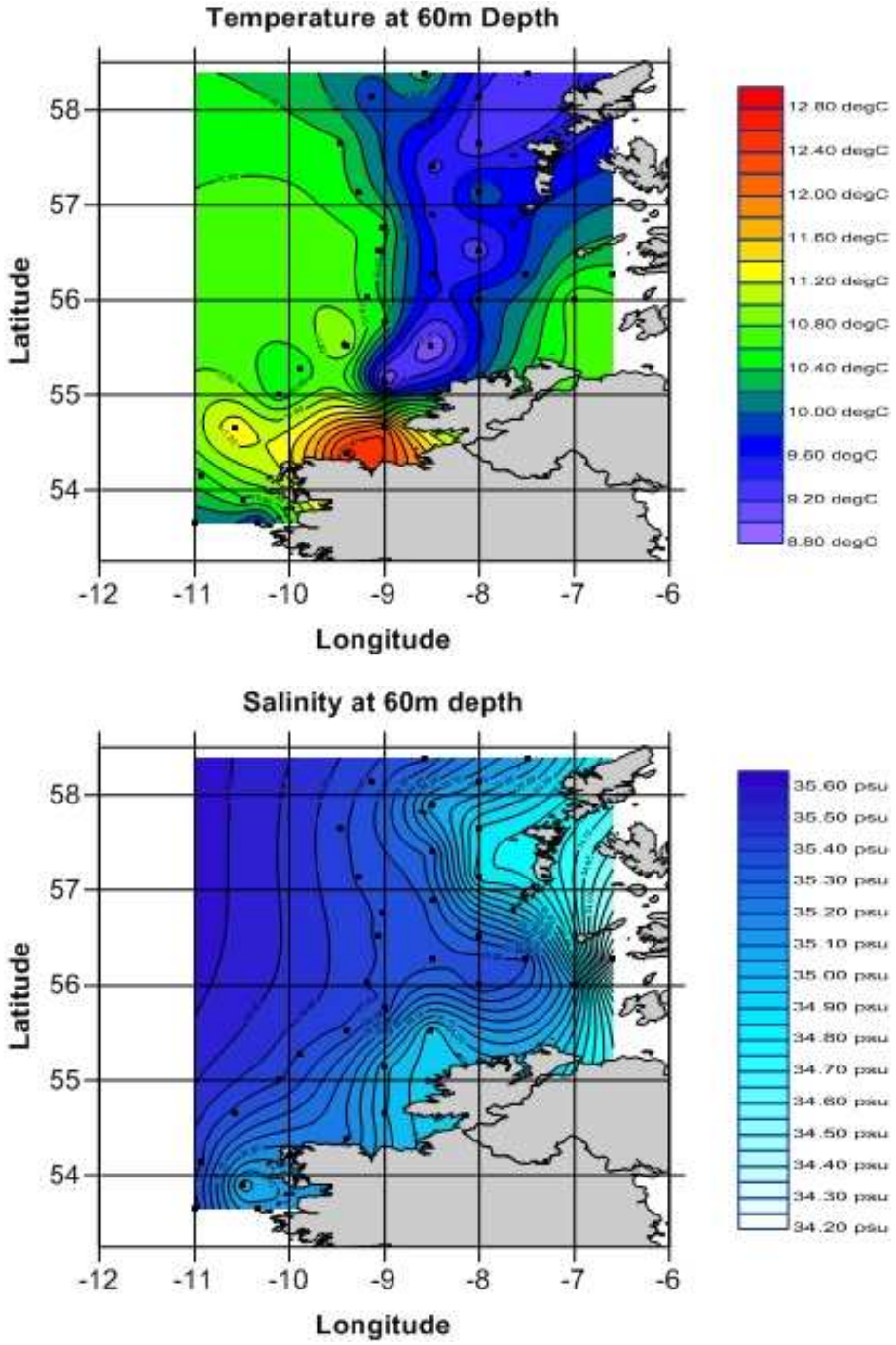


Figure 9. Horizontal temperature (top panel) and salinity (bottom panel) at 60m subsurface as derived from vertical CTD cast data (black squares). Northwest herring survey, June/July 2013.

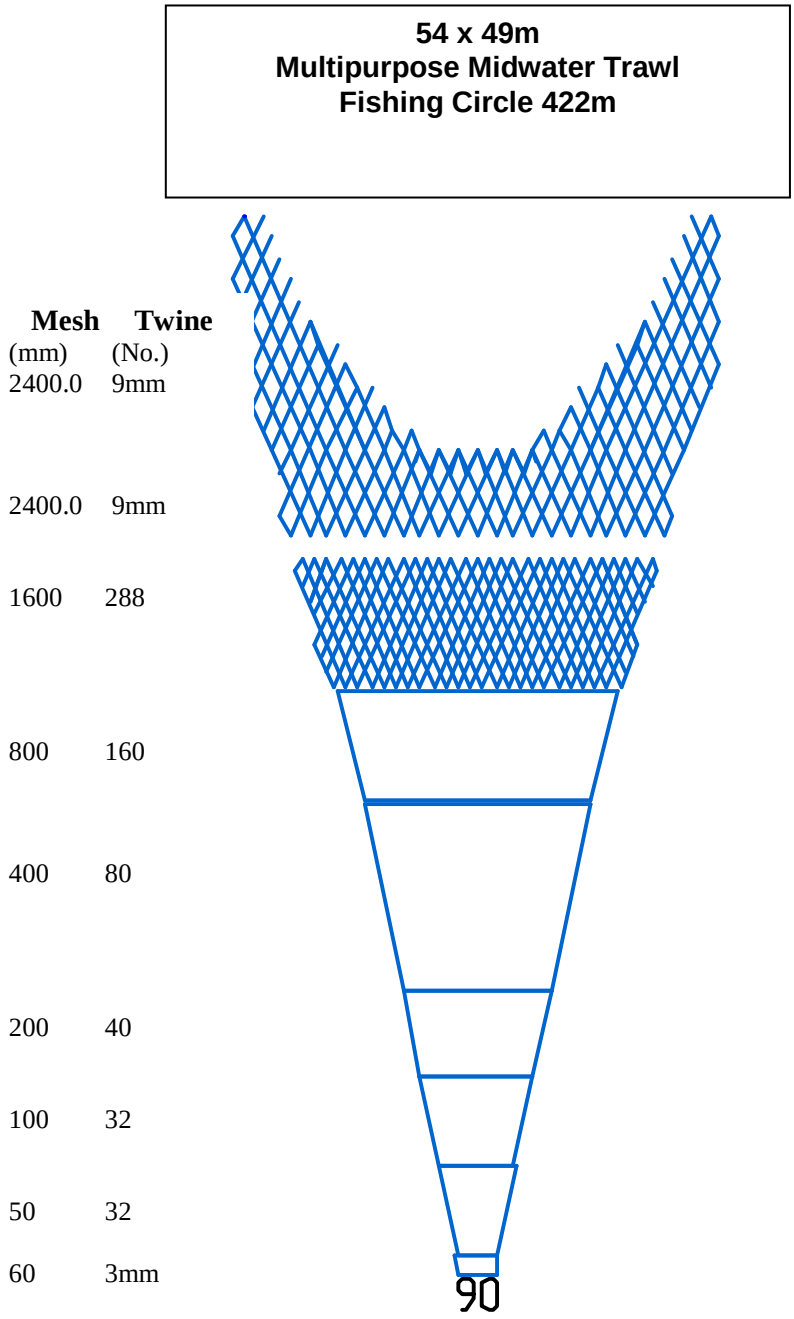


Figure 10. Celtic Explorer multi-purpose midwater trawl employed during the Northwest herring acoustic survey, June\July 2013.

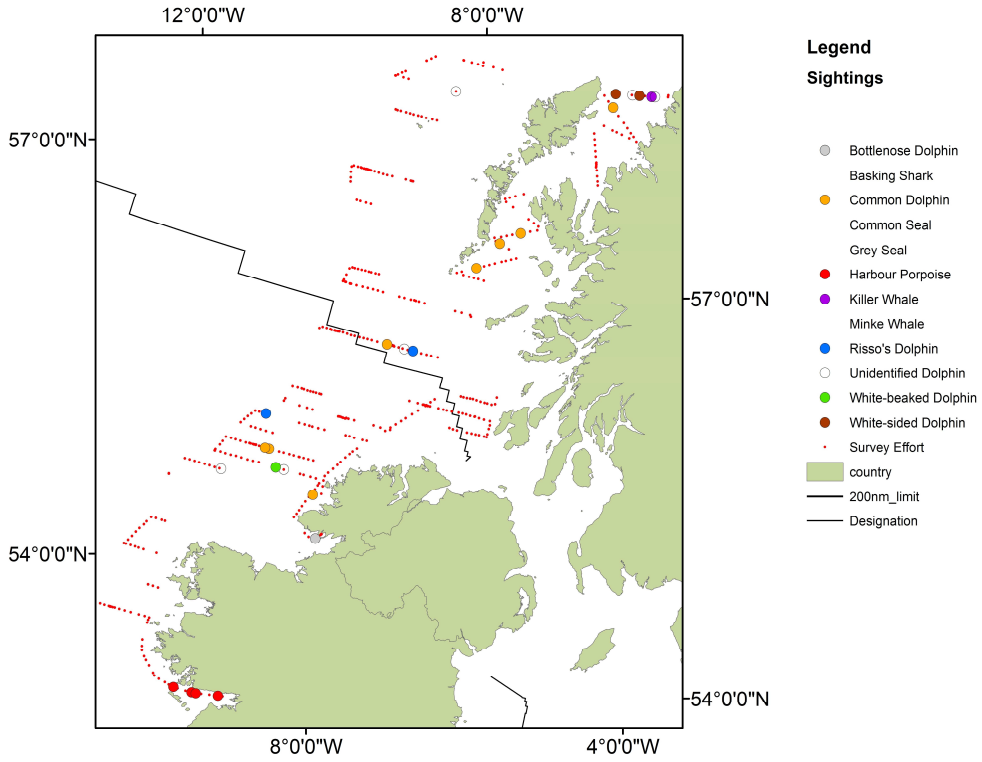


Figure 11. Positions of cetacean sightings, Northwest herring survey, June/July 2013.

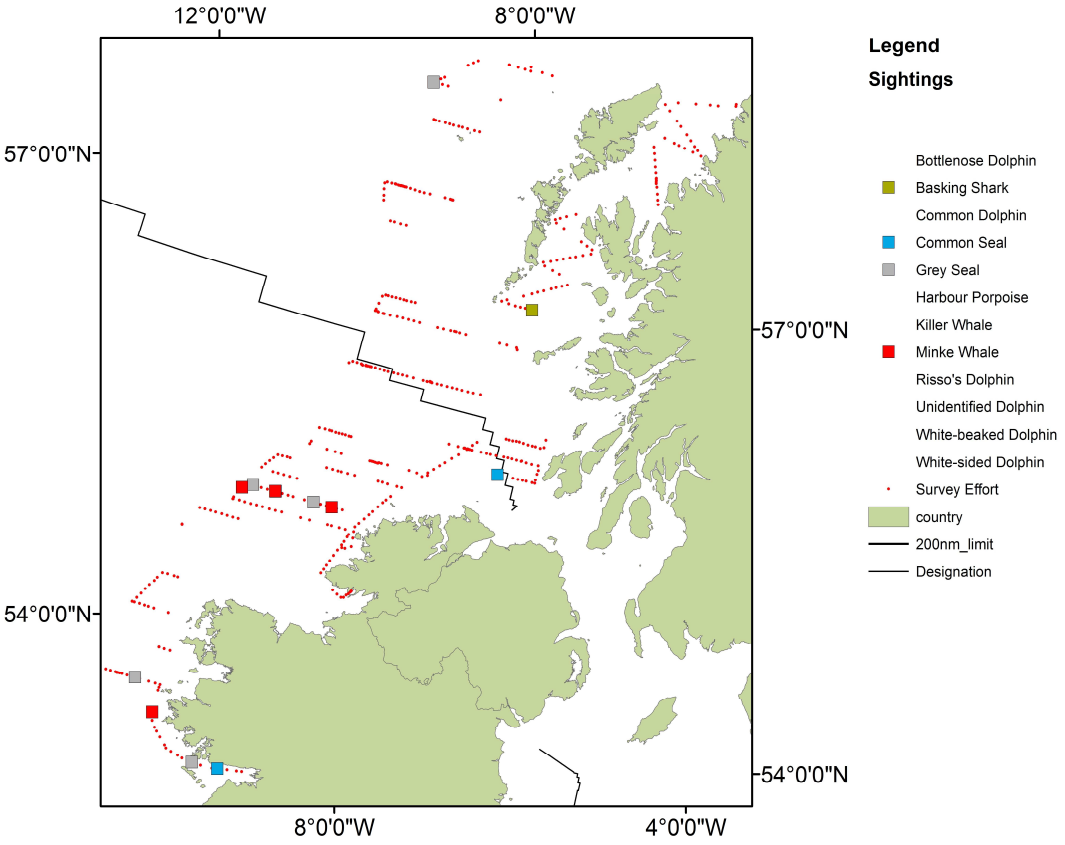
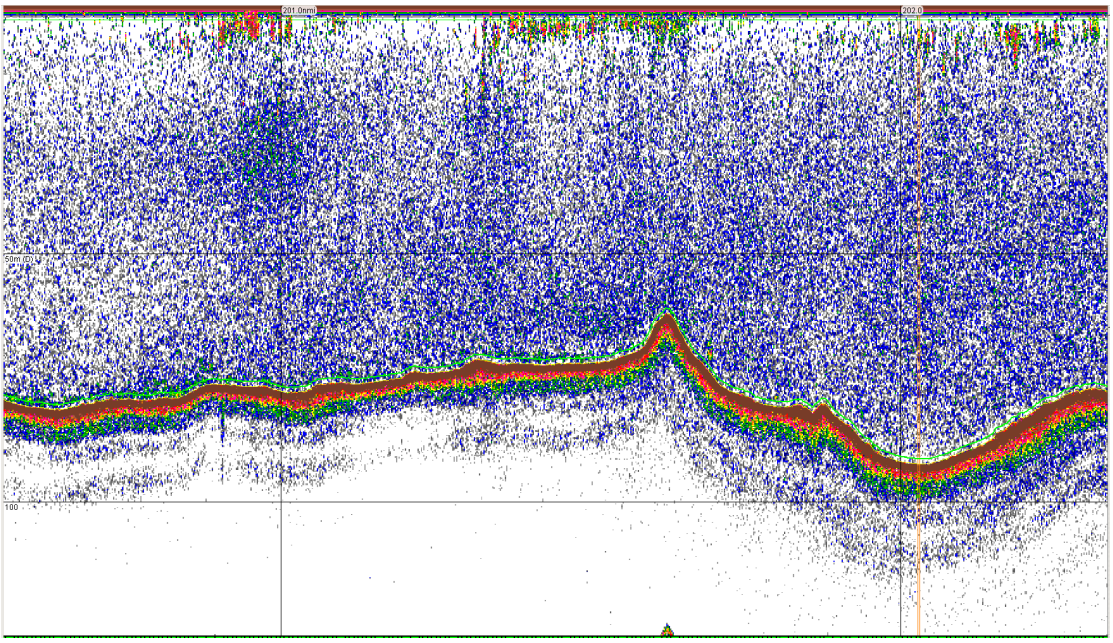
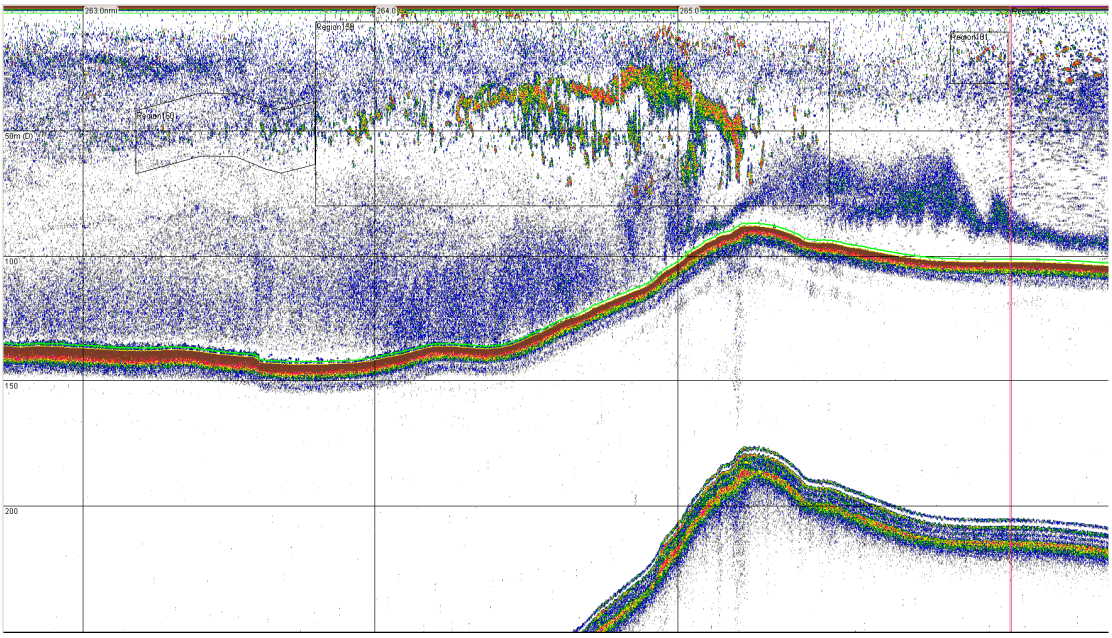


Figure 12. Positions of cetacean sightings, Northwest herring survey, June/July 2013.

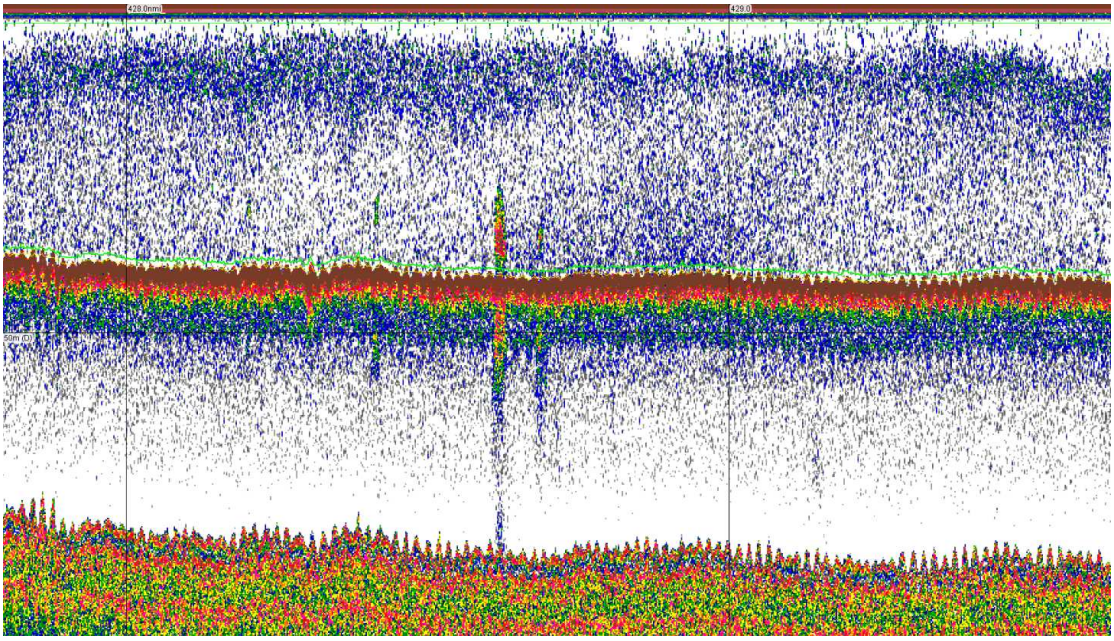
Appendix 1: Echograms prior to fishing



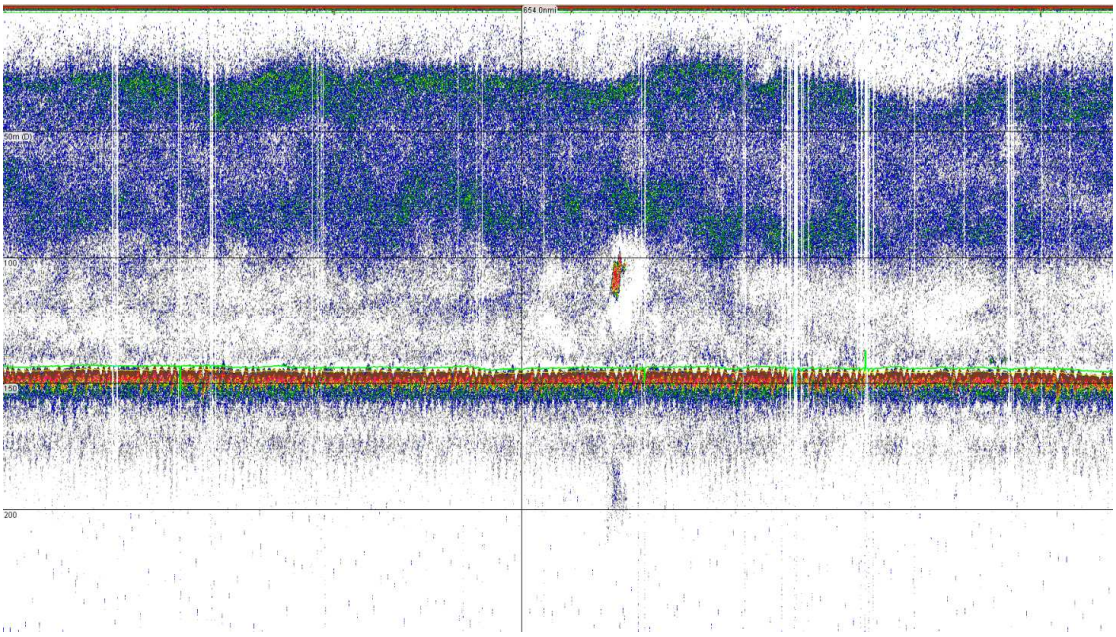
Haul 1. 25/6/13. A scattering of surface marks in the Minch. A small number of lesser sandeel were meshed in the cod-end. Vertical lines are 1 nmi, horizontal lines are 50m.



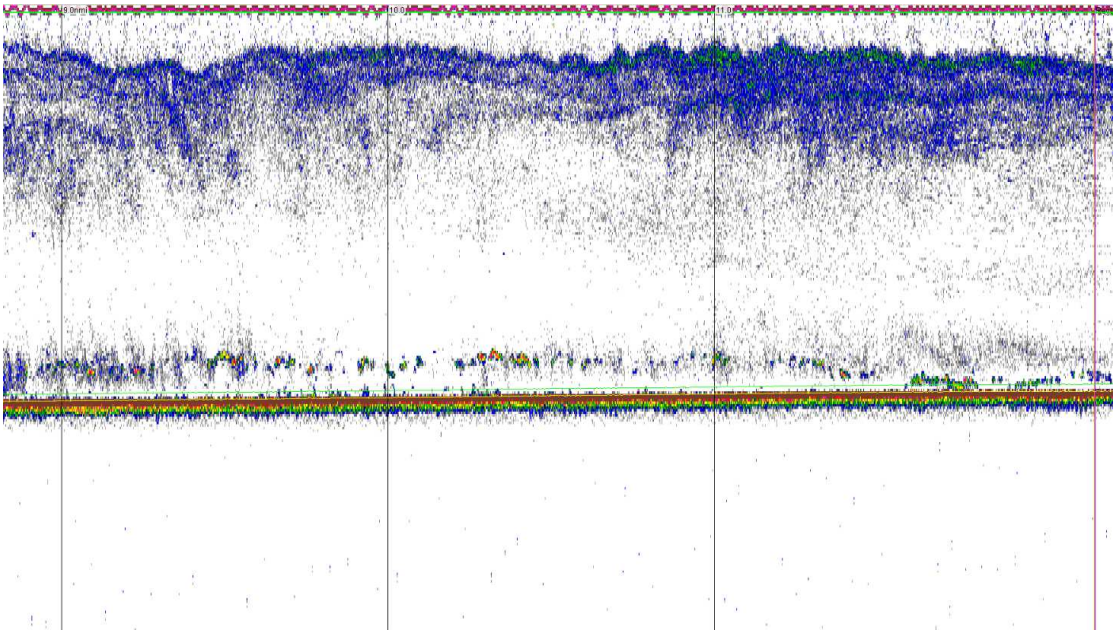
Haul 2. 26/6/13. Mid-water marks in the Minch. Juvenile gadoids meshed in the cod-end.



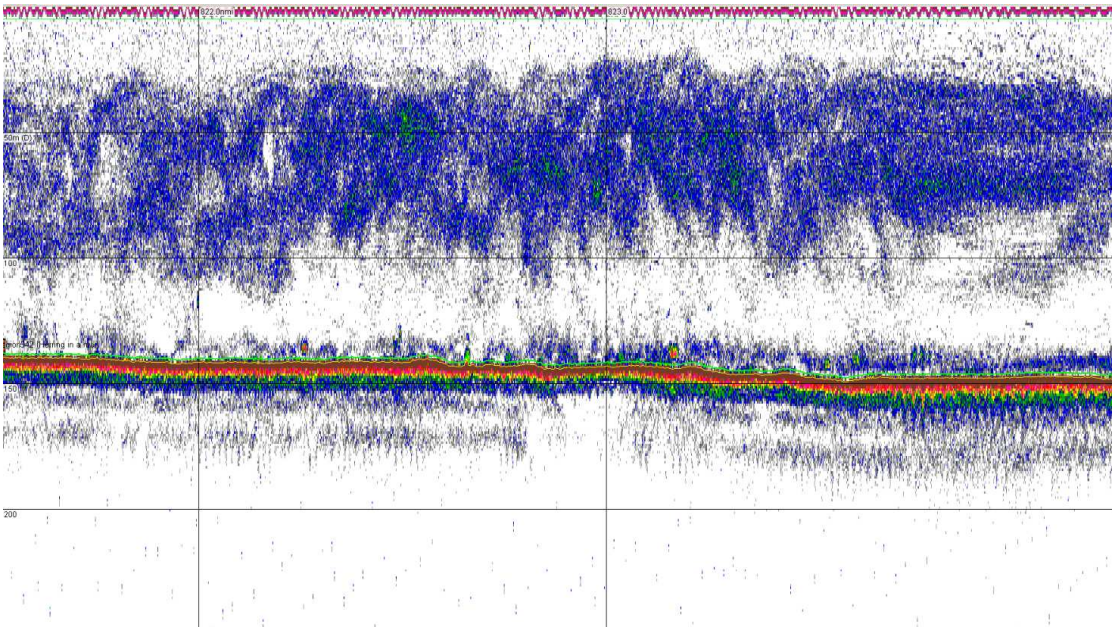
Haul 3. 27/6/13. Almost 200kg of herring sampled on the first transect west of the Hebrides.



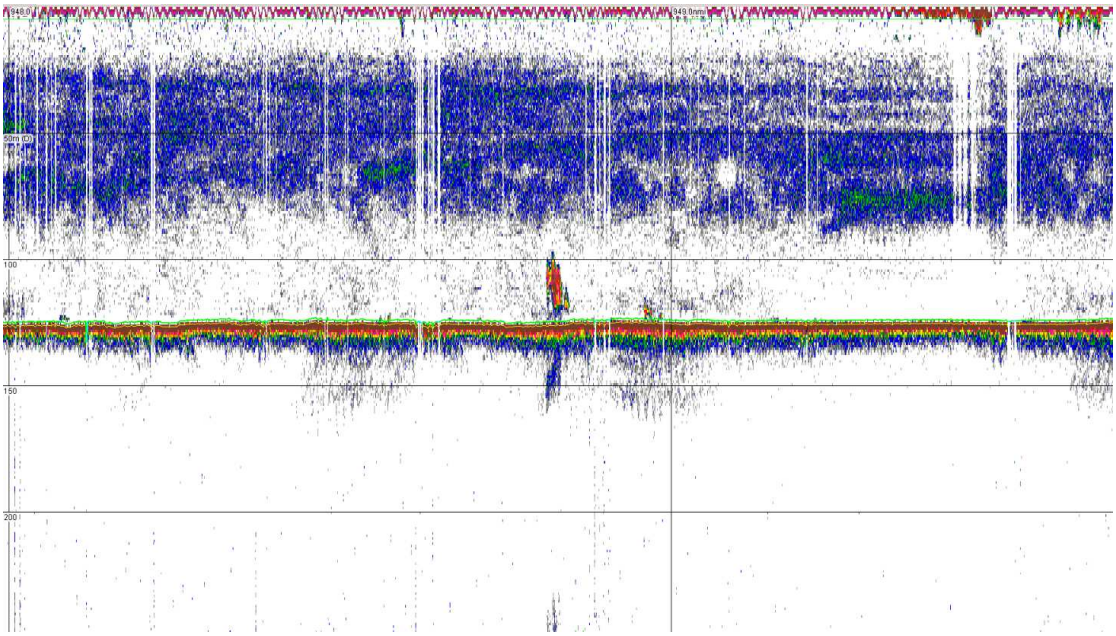
Haul 4. 28/6/13. This mid-water mark of herring near the shelf edge dived under the net on the first pass. On the second pass 91kg of herring were sampled.



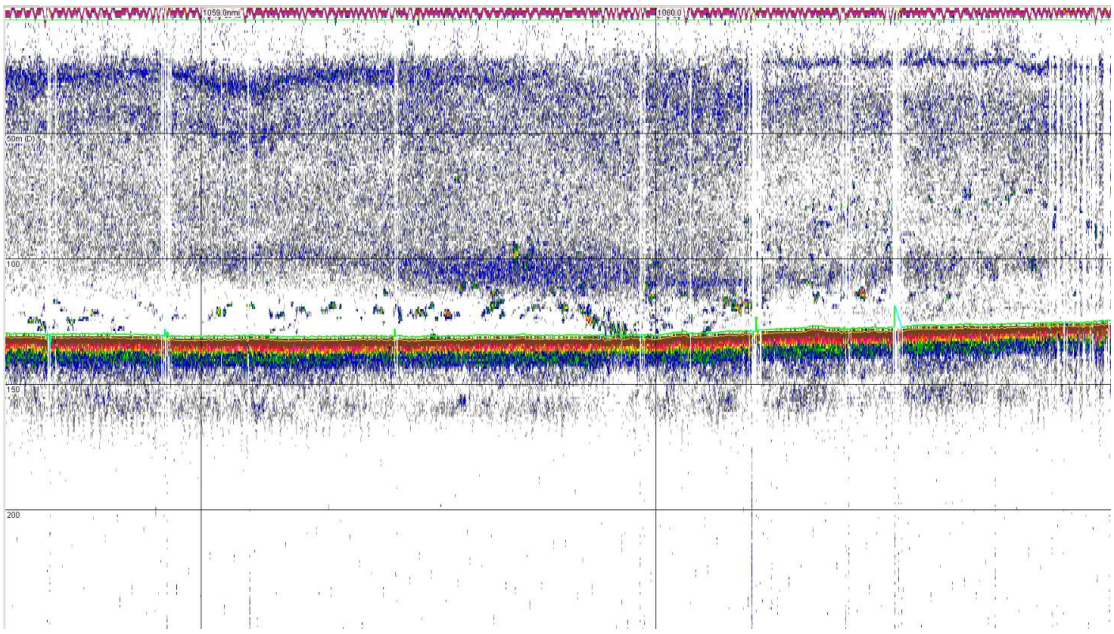
Haul 5. 28/6/13. Light, scattered marks of herring close to the seabed south west of St. Kilda.



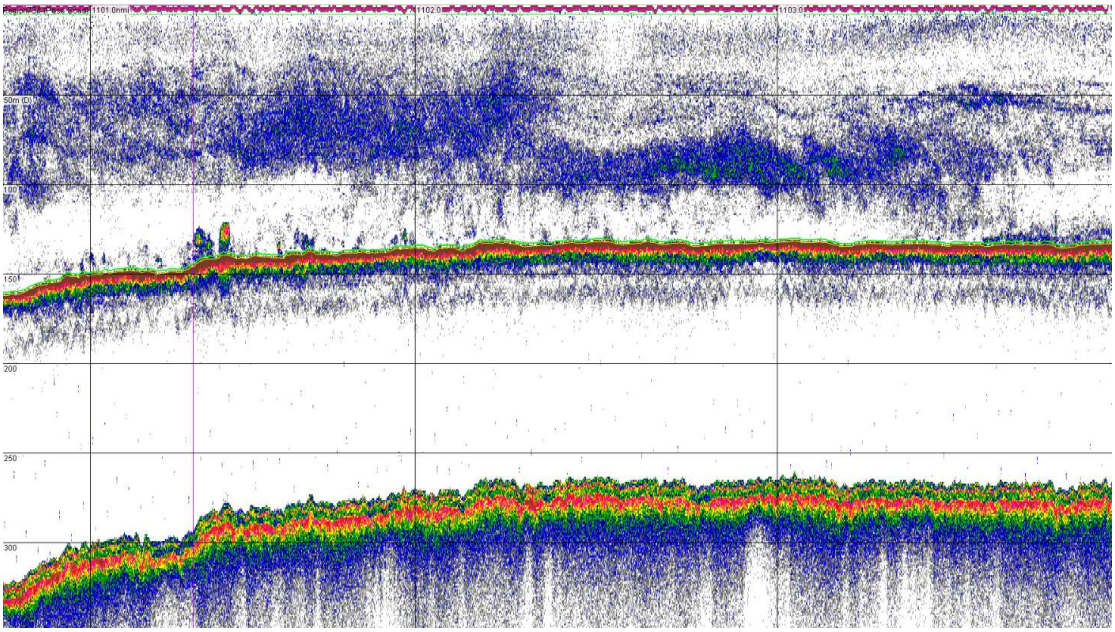
Haul 6. 29/6/13. Two small marks of herring mixed with mackerel close to the sea bed near the shelf break.



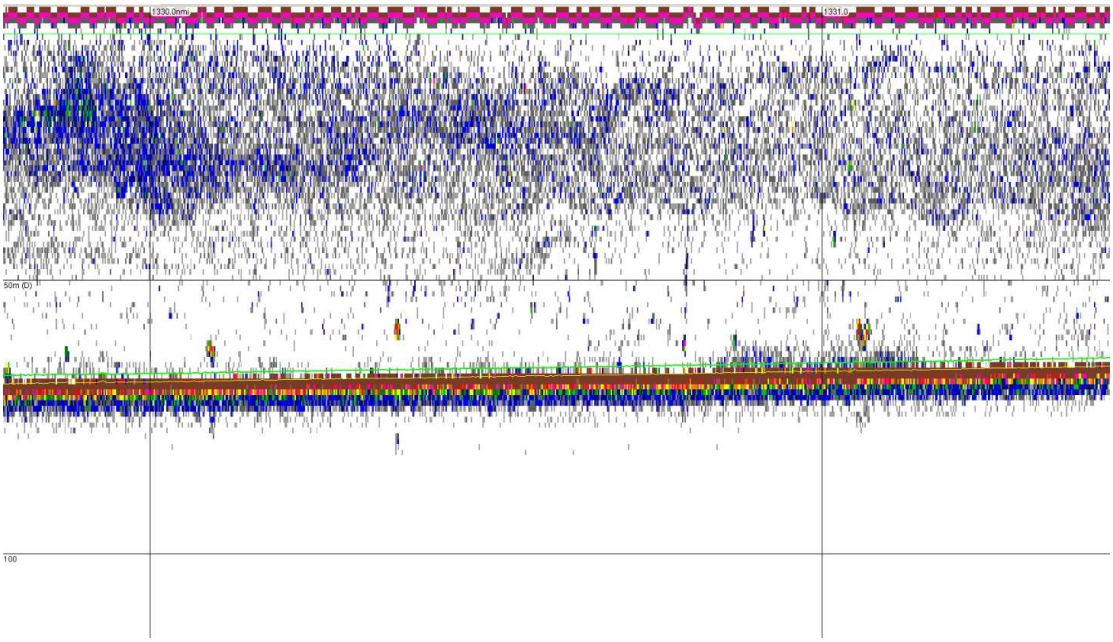
Haul 7. 30/6/13. A large school of herring in stat rectangle 42E1.



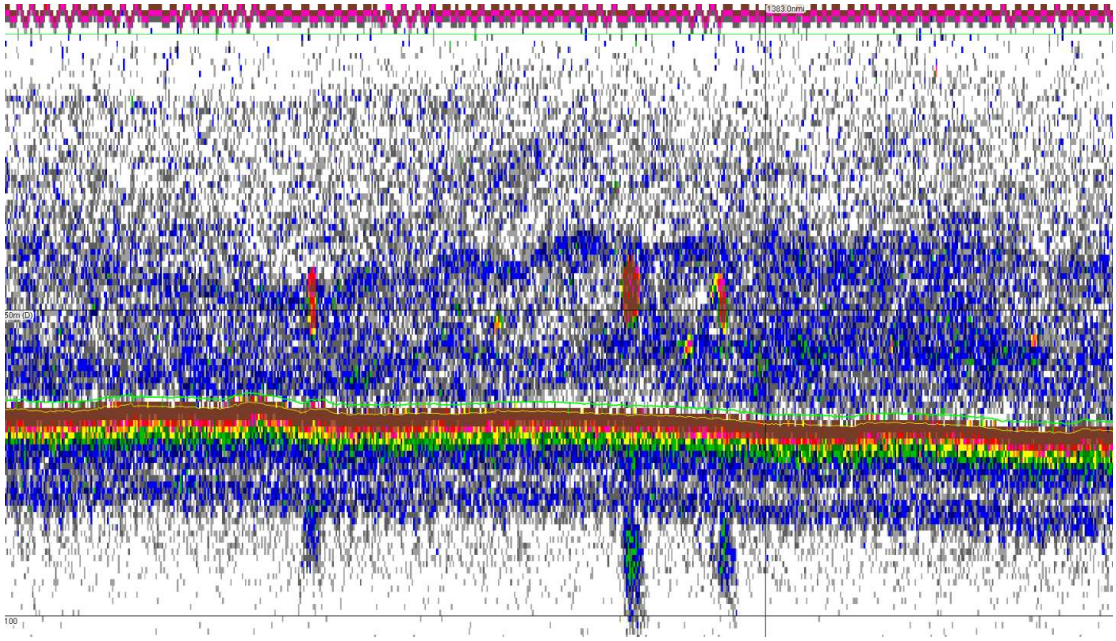
Haul 8. 1/7/13. Scattered layer of herring, also in stat rectangle 42E1.



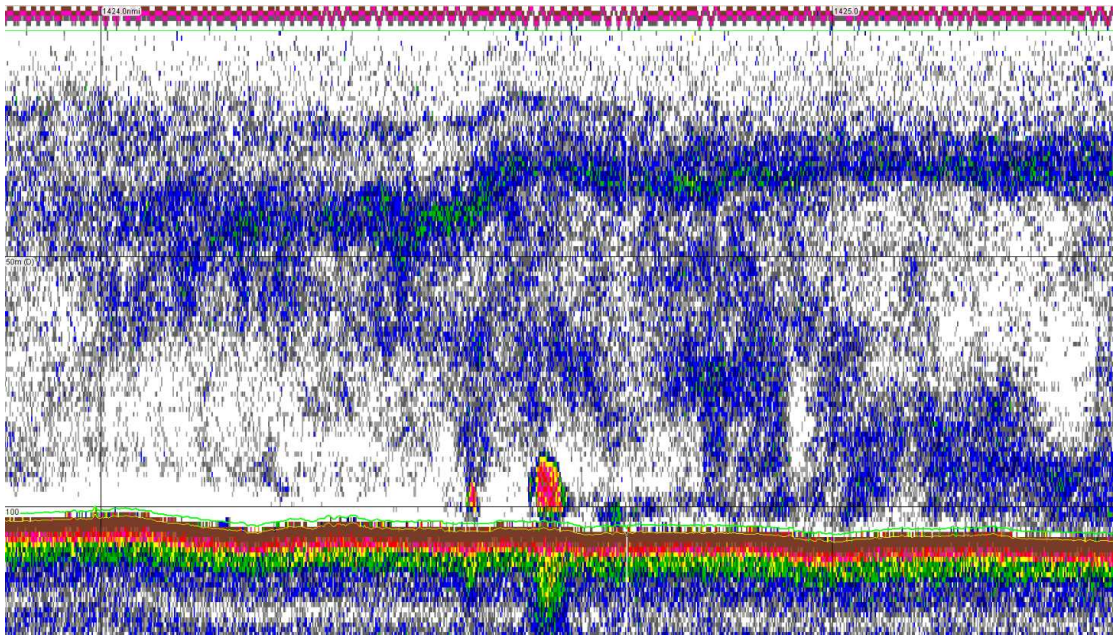
Haul 9. 1/7/13. A mixture of herring (52%), boarfish (17%) and mackerel (31%) close to the shelf edge in stat rectangle 42E1.



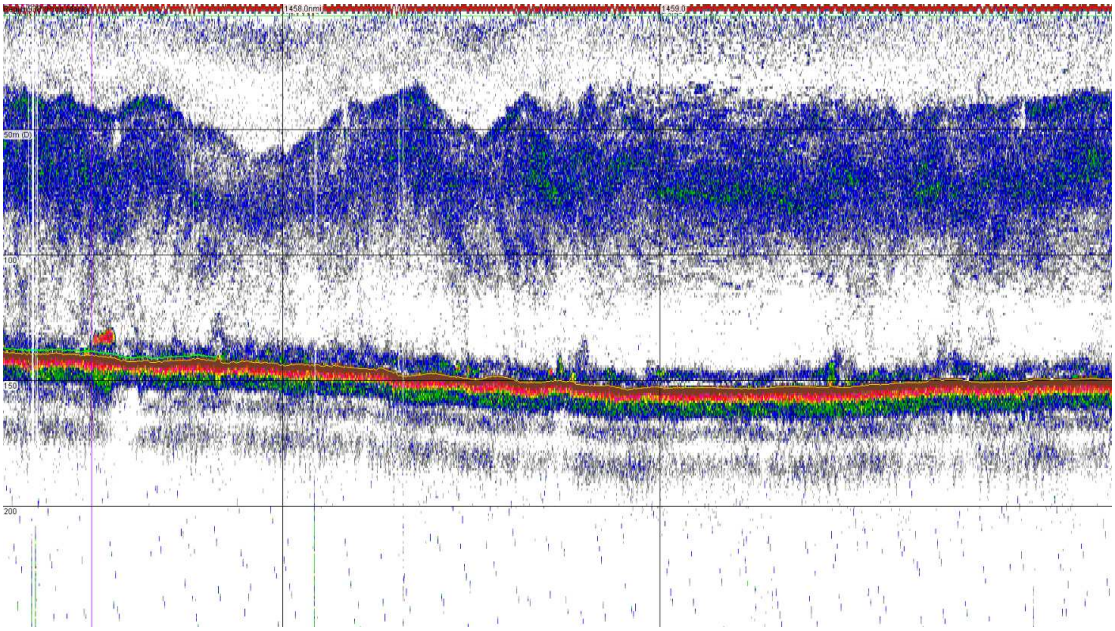
Haul 10. 2/7/13. Very small marks of sprat south of Tiree.



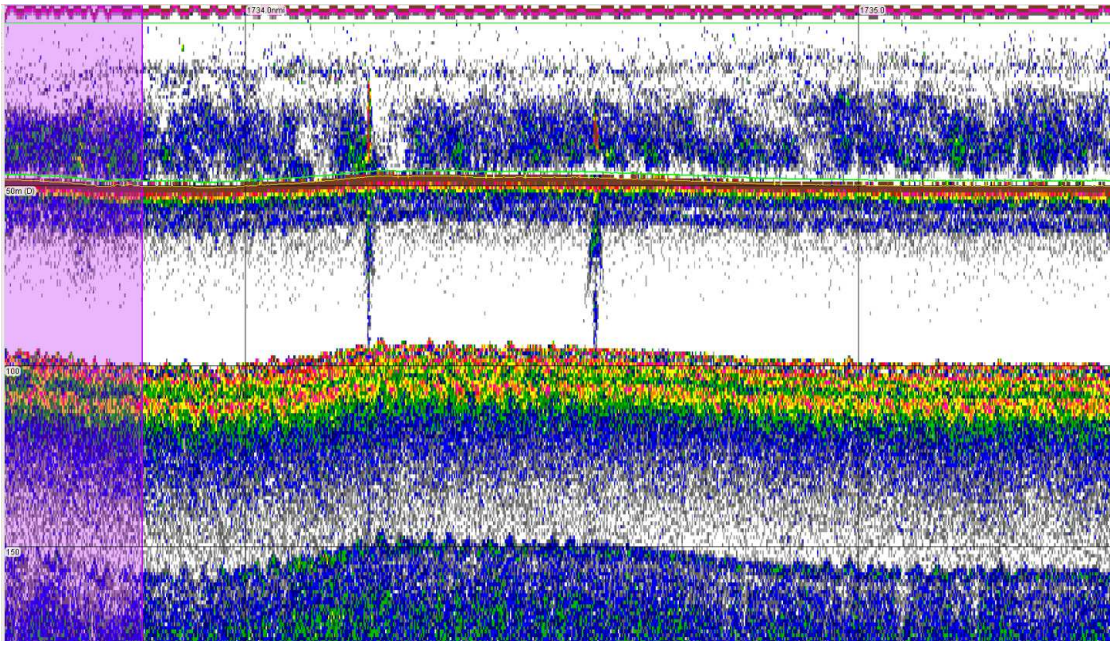
Haul 11. 3/7/13. Dense marks south west of Tiree. The largest marks could not be sampled but one smaller mark, seen on the headline transducer, yielded 20kg of sprat.



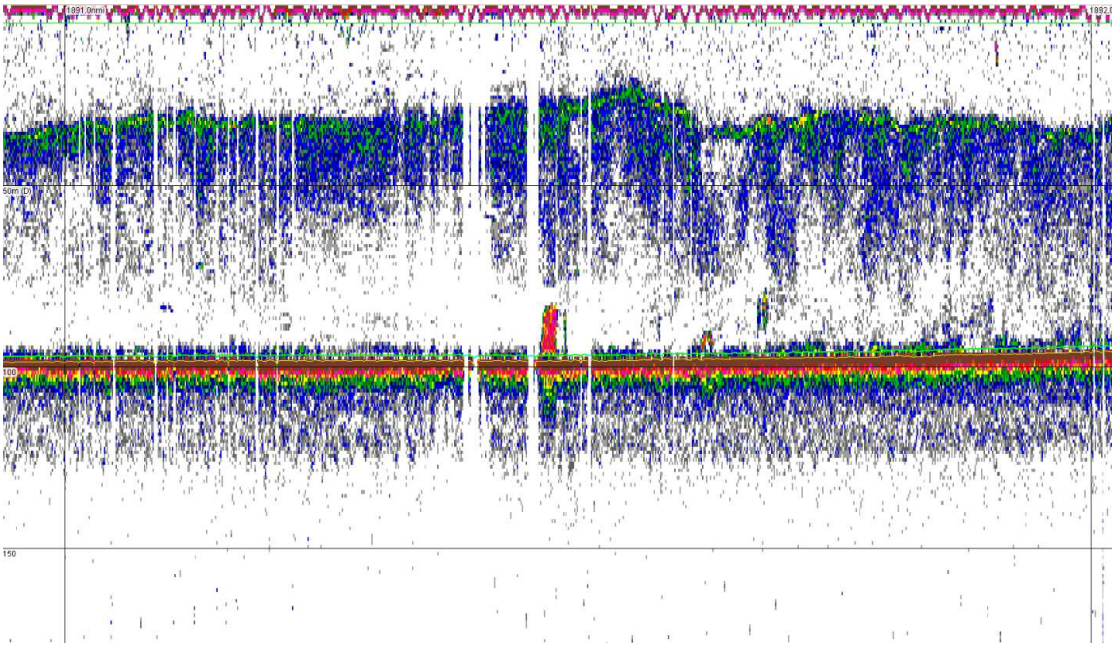
Haul 12. 3/7/13. Large mark seen in stat rectangle 41E1. The mark was not seen on the headline transducer, void haul.



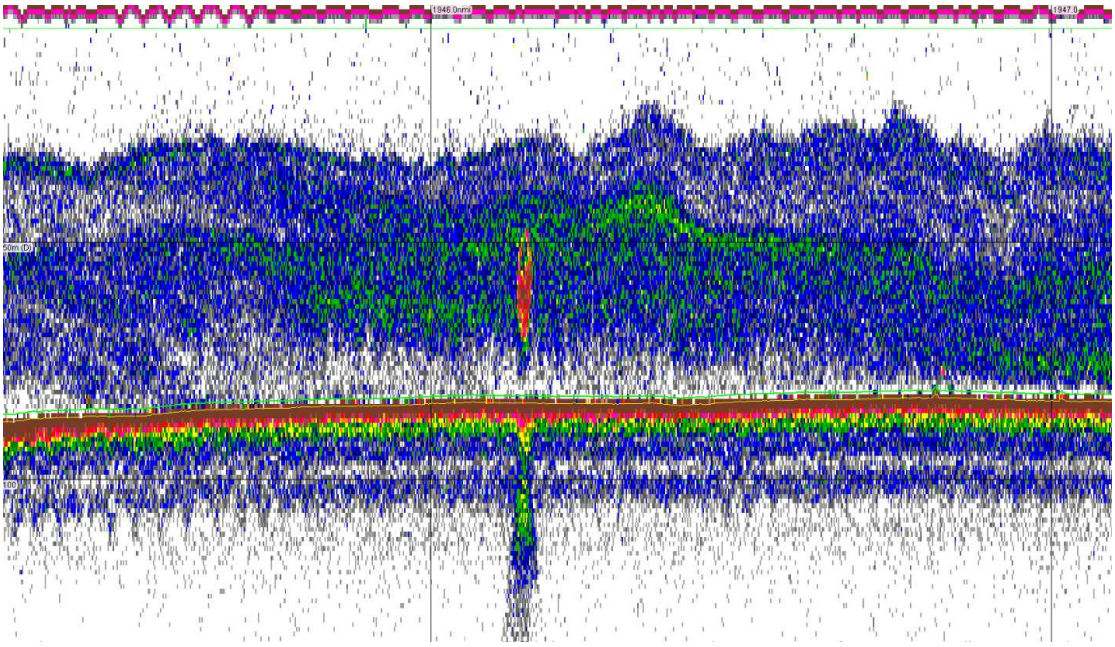
Haul 13. 3/7/13. A mixture of herring and mackerel near the shelf edge.



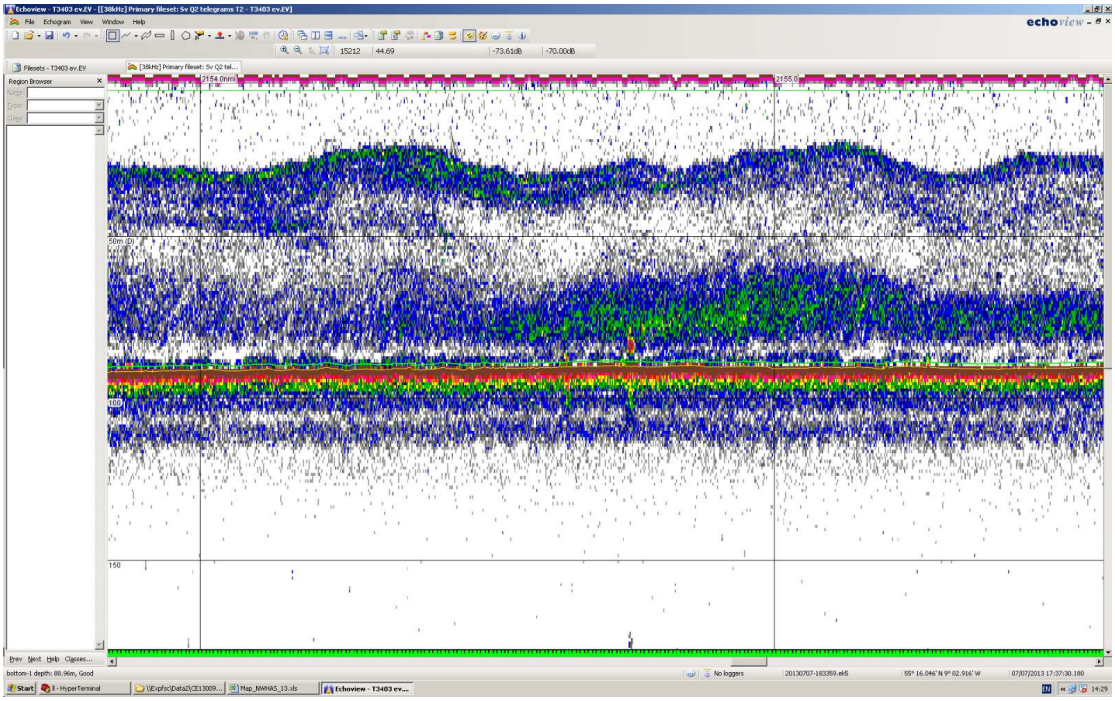
Haul 14. 5/7/13. Two tall, thin, dense marks of herring sampled in stat rectangle 40E2.



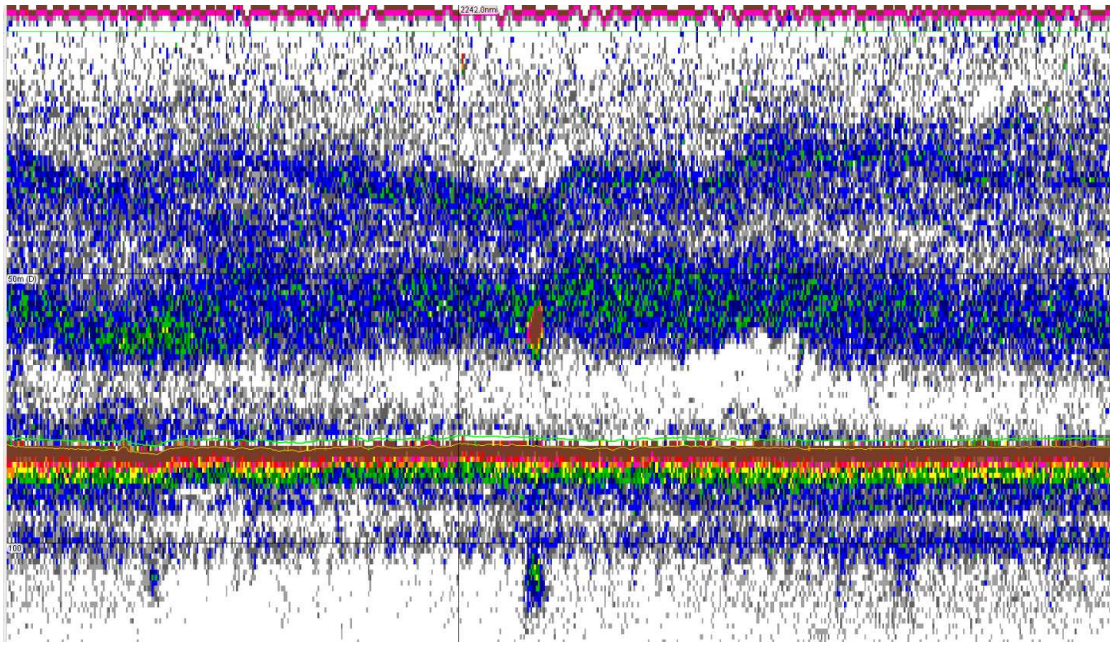
Haul 15. 6/7/13. Roughly 500kg of herring (52%) and boarfish (47%) were sampled from this mark.



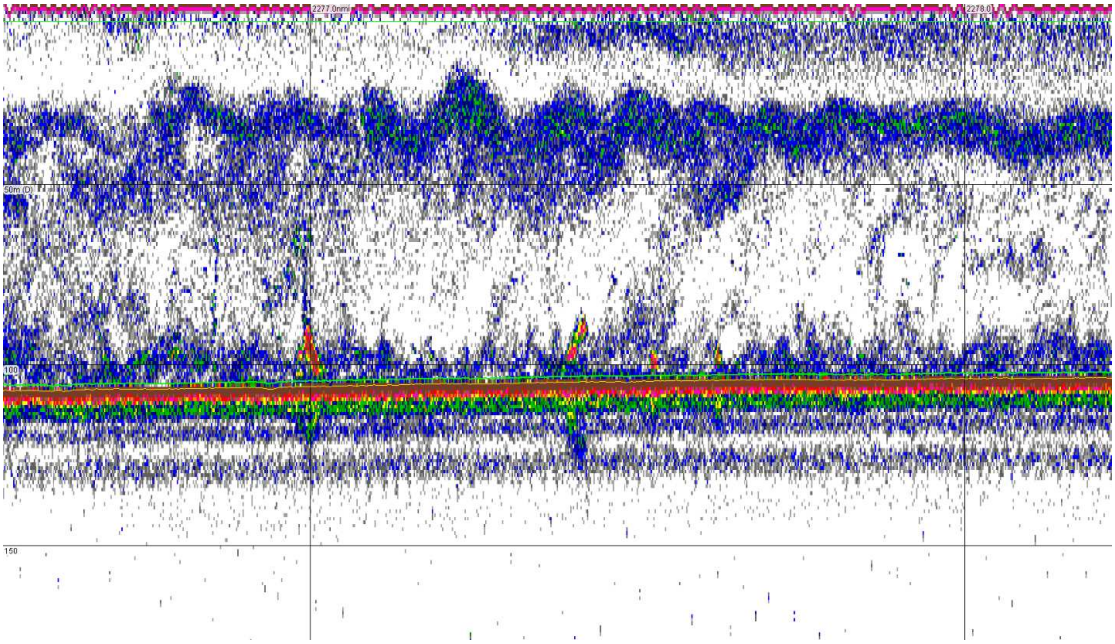
Haul 16. 6/7/13. This large, dense, herring-like mark north west of Donegal was not seen again on the headline transducer. Void haul.



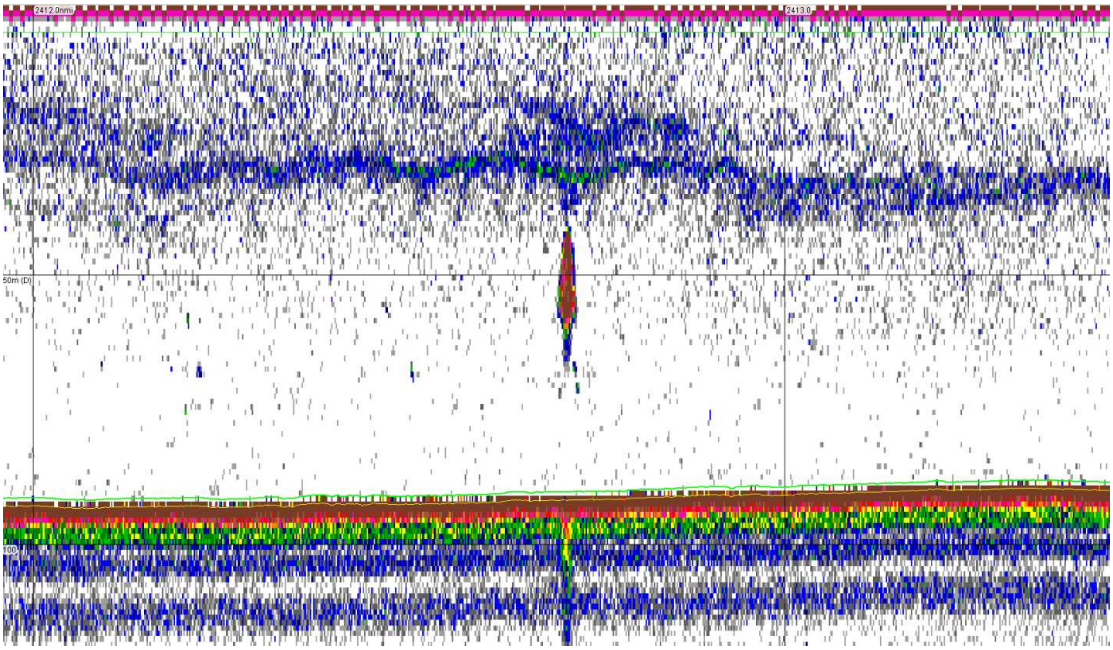
Haul 17. 7/7/13. This small mark west of Tory Island, along with a larger mark not pictured, produced 750kg of herring.



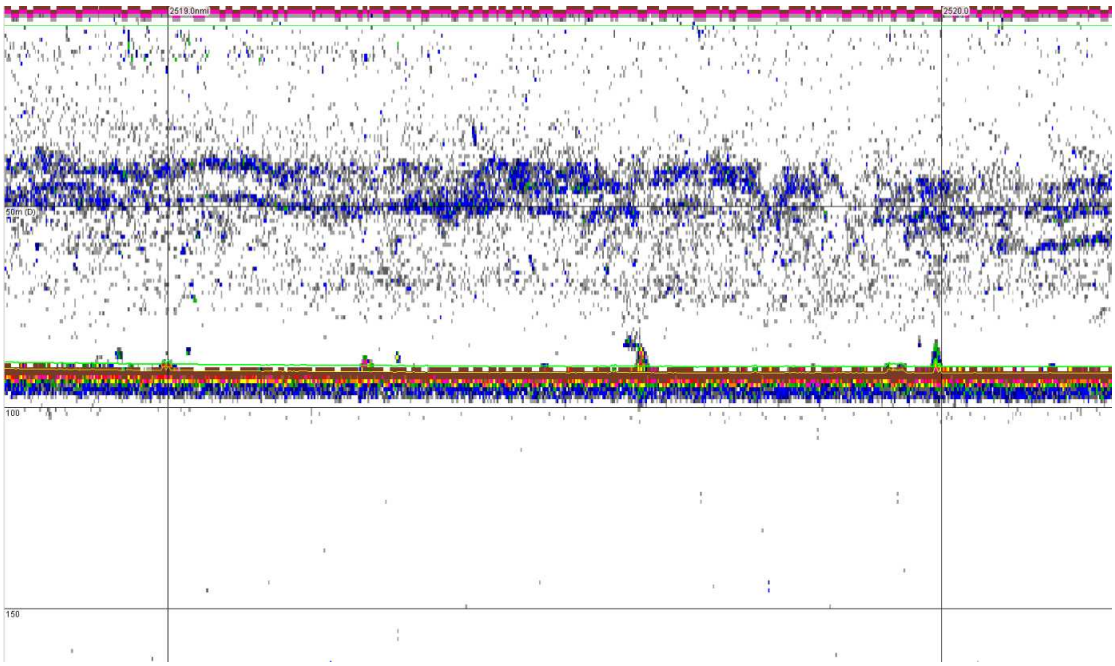
Haul 18. 8/7/13. 750kg of herring were caught from this mark.



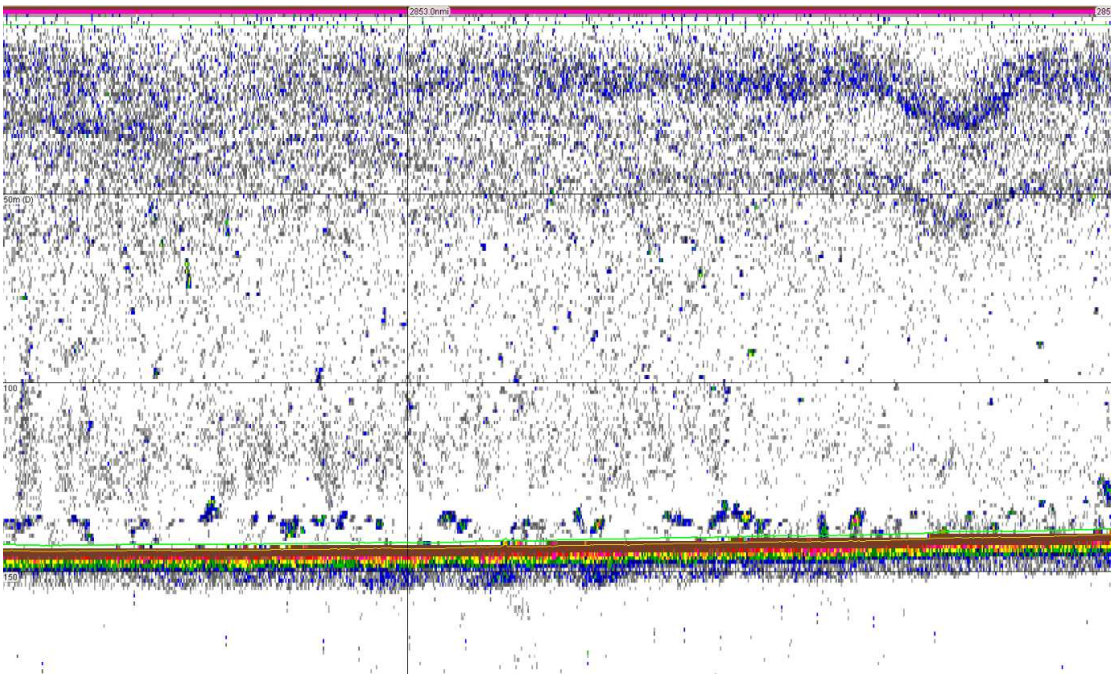
Haul 19. 8/7/13. Marks of herring seen close to the shelf edge, west of Donegal. Roughly 600Kg of herring (82%) and mackerel (18%) caught in total.



Haul 20. 9/7/13. Large, dense, mid-water mark in stat rectangle 38E0. The mark was not seen again on the headline transducer. Void haul.



Haul 21. 9/7/13. Very small marks on the seabed further south in start rectangle 38E0. One mark was seen on the headline transducer, which yielded 18kg of herring, gurnard and other assorted species.



Haul 22. 11/7/13. A scattering of bottom marks west of Inishboffin yielded 260kg of mostly blue whiting.